URE'S DICTIONARY

OF

ARTS, MANUFACTURES, AND MINES

CONTAINING

A CLEAR EXPOSITION OF THEIR PRINCIPLES AND PRACTICE

BY

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ASSISTED BY NUMEROUS CONTRIBUTORS
EMINENT IN SCIENCE AND FAMILIAR WITH MANUFACTURES

VOL. IV.

SUPPLEMENT

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PREFACE.

It was discovered when the last pages of the Third Volume of this Dictionary were printed, in 1875, that several of the articles in the earlier portions of the work required some additions, owing to the advances which had been made in the useful applications of science, and that new articles were necessary to record the progress of several examples of inventive ingenuity.

To meet this necessity it was determined to produce a Supplementary Volume, in which all the required additions should be made, and all improvements, and new applications of value, carefully recorded.

It is hoped this has been completed in a satisfactory manner. It is believed that this Supplement will be found to include everything relating to Arts, Manufactures, and Mines which has claimed attention since the publication of the previous volumes, and to represent faithfully the state of these divisions of human industry up to the commencement of the present year.

Several new articles have been introduced. The following names will show that these have been written by reliable authorities:—

Names of Authors.	Articles written.
EMERSON BAINBRIDGE, Esq. Mining Engineer, Sheffield.	*Safety Lamp (in part): Heat.*
Capt. JOHN BARKELL, M.E. Ballamarkish, Isle of Man.	*Dialling.*
Prof. GUSTAV BISCHOF, F.C.S.	*Spongy Iron Filter.*
J. COLEMAN, Esq., York. Commissioner Philadelphia Centenary Exhibition.	*Agricultural Mechanics.*

NAMES OF AUTHORS.	ARTICLES WRITTEN.
EDWARD A. COWPER, M.I.C.E.	*Furnace and Hot Blast Stoves (in part).*
JOHN DARLINGTON, Esq. Mining Engineer &c.	*Dressing Ores: Sand Pump: Rock Boring Machines.*
JAMES HENDERSON, C.E.	*Natural Refrigeration.*
JAMES HIGGIN, F.C.S. Manchester.	*Calico-Printing.*
CHEVALIER JERVIS. Conservator of the Museum, Turin.	*Mineral Statistics of Italy, and Notes.*
C. T. KINGZETT, F.C.S.	*Sanitas.*
EDMOND LINDON (*the late*). Bombay.	*Gold in Southern India.*
RICHARD MEADE, Esq. Assistant Keeper of Mining Records.	*Boots and Shoes, Manufacture by Machinery. Statistics (in part).*
CAPT. FRANCIS OATS. Mining Engineer, Kimberley, South Africa.	*Diamonds, Gold, and Copper, &c. in Africa.*
H. McCALL, Esq. Lisburn, Ireland.	*Linen and Flax.*
DR. ROBERT OXLAND, F.C.S. Plymouth.	*Ore Calciner.*
T. J. PEARSALL, Esq.	*Printing in Colours (in part).*
T. B. PROVIS, Esq. Mining Engineer, Camborne.	*The Barrow Borer.*
S. B. J. SKERTCHLY, Esq. F.G.S. Geological Survey of England and Wales.	*Flint. Fur.*
ANDREW TAYLOR, Esq. F.C.S. Edinburgh.	*Mineral Oils Industry.*
J. W. TURNER, Esq. Bradford.	*Wool: Worsted.*

I am also under considerable obligations for information furnished—in many cases at considerable personal labour—and for the contribution of matter giving the results of original enquiries in connection with sundry other articles—to those men of science, manufacturers and others, named in the list below, whose valued assistance I respectfully acknowledge.

NAMES OF AUTHORS.	ARTICLES CONTRIBUTED.
SIR JOHN G. W. ALLEYNE, BART.	*The Application of Spectrum Analysis to the Detection of Phosphorus in Iron.*
MESSRS. BAINBRIDGE AND HALL	*Peat.*
PROF. W. F. BARRET	*Iron and other Magnetic Metals.*

NAMES OF AUTHORS.	ARTICLES CONTRIBUTED.
HILARY BAUERMAN, Esq., F.G.S.	*Lignite, Silver Samples, &c.*
W. MORGAN BROWN, Esq.	*Sympalmograph.*
I. LOWTHIAN BELL, M.P., F.R.S.	*Iron and Steel.*
THOMAS DAVEY, Leeds	*Pumping Engines, Underground.*
N. B. DOWNING, Esq.	*Paper Pulp.*
M. E. LAMÉ FLEURY, Minister of Mines, Paris.	*Mineral Statistics of France.*
W. GALLOWAY, Esq. Inspector of Collieries.	*The Influence of Coal Dust in producing Colliery Explosions.*
W. HUSBAND, C.E.	*Pneumatic Stamps.*
THOMAS B. JORDAN, Esq.	*Boring Machines.*
M. MAUMENÉ, Paris	*Alcoholometry and Wine.*
JOHN MOSS, Esq., F.C.S.	*Vaseline.*
J. ARTHUR PHILLIPS, F.G.S.	*Pyrites, &c. &c.*
FREDERICK POTTER, Esq. Nagasaki, Japan.	*Coal Mines in Japan.*
A. RANSOME, Esq., M.I.C.E.	*Wood-Working Machinery.*
Dr. AUGUSTUS VOELCKER, F.R.S.	*Phosphatic Minerals.*
CHARLES WOOD, Esq., C.E. Middlesborough.	*Slag, Utilisation of.*

It is right that I should also express my obligations to such journals as the *Engineer*, *Engineering*, *Iron*, the *English Mechanic*, the *Chemical News*, &c.; and to the *Transactions of the American Institute of Mining Engineers*, the *Journal of the Franklin Institute*, the *American Journal of Science and Art*, the *Engineering and Mining Journal of New York*, and others. It is believed, however, that sufficient references have been made, throughout the volume, to the sources from which information has been derived.

From the readiness with which assistance has been given, and reliable information supplied, it is believed that this Supplementary Volume will maintain the high character for usefulness which this Dictionary has secured.

ROBERT HUNT, F.R.S.

Keeper of Mining Records.

March 12, 1878.

A DICTIONARY

OF

ARTS, MANUFACTURES, AND MINES.

A

'**AACHEN INDIGO.**' REIMANN states that this dye stuff, which has lately come into the market, is identical with 'indulin,' 'artificial indigo,' and 'benzalin'—substances produced by the action of nitrite of potassium on hydrochloride of aniline. —*Chem. Centr.* 1875.

ABIETIC ACID. ('ABIETENE and ABIETIN,' vol. i. p. 2.) (*A. abiétique*, Fr.; *Die Tannenharzsäure*, Ger.) This acid is formed by digesting colophony in alcohol for a considerable period. A mixture of concentrated alcoholic abietic acid and glycerin deposit, after standing for fourteen days, small white crystals of Abietin, melting at 125°, and having the composition $C^{44}H^{66}O^{8} = 3C^{44}H^{64}O^{5} + C^{3}H^{8}O^{3} - 6H^{2}O$.—MALY, *Ann. Ch. Pharm.* cxlix. 244. See COLOPHONY.

ABROMA. A genus of the Sterculiaceous family, growing in India, Java, &c. From the bark a very useful fibre is separated by maceration in stagnant water. The cord made from it is exceedingly strong.

ABRUS. A leguminous plant; a native of the East and West Indies and the Mauritius. It produces small scarlet coloured seeds, nearly globular, with a black scar. They are employed in India for weights, under the name of Rati.

ACACIA. (Vol. i. p. 3.) The ash of the seeds of the *Acacia nilotica* have been examined by O. POPP, and shown to be similar in composition to beans and peas, and might probably be used for food.

ACETATE OF AMMONIUM. (*Acétate d'ammoniaque*, Fr.; *Das essigsaure Ammoniak*, Ger.) This salt, as obtained in Commerce, is an acid salt, and contains acetamide if it has been prepared by heat. It may be obtained pure by evaporating the solution of the commercial salt with an excess of ammonia, completing the evaporation at a low temperature. It is then allowed to cool in ammonia vapour, then broken up, and permitted to remain for several months in a jar filled with ammonia. —M. BERTHELOT, *Bull. Soc. Chem.*

ACETYLENE. (Vol. i. p. 16.) Detection of, in coal gas. See COAL GAS.

ACETYLCHRYSAZIN. One of the hydrocarbons obtained from a mixture of solid hydrocarbons, which have a higher boiling point than anthracene, by treating this mixture with cold sulphide of carbon. See CHRYSAZIN and ACETYL, WATTS'S *Dictionary of Chemistry*.

ACHREMATITE. (ἀχρήματος, *inops*.) A new molybdo-arseniate of lead from Mexico, so named from the circumstance that Professor MALLET, of the University of Virginia, received the specimen as an ore of silver, though practically it contains none. The following is the result of an analysis made by the Professor. The mineral having been previously dried at 70° C.:—

	1	2	3
As^2O^5	[illegible]	[illegible]	15·75
P^2O^5	·03	[illegible]	·02
M^*O^*	4·58	4·40	4·19
Cl	1·89	1·58	1·88
F.		traces	
Pb (calculated for Cl as above) .	5·51	6·48	6·18
Pb O (remaining) . . .	60·35	63·32	56·77
Cu		traces	
Ag		traces	
Fe^2O^3	9·93	8·53	13·08
H^2O (driven off at low heat) .	1·63	1·38	2·27
	99·81	100·27	99·44

ACRYLIC *Series of Acids.* $C^nH^{2n-2}O^2$. Acids occurring in the vegetable or animal organisms, or obtained from natural products by the saponification of natural fats. See OLEIN and OLEIC ACID. Consult WATTS's *Dictionary of Chemistry*—Supplement—for ORGANIC ACIDS.

ADAMELLOGRANITE. A ferro-magnesia-mica, found in the Adamello group in the Tyrol. It is a variety of granite allied to LEPIDOMELANE, and to the magnesia-mica from the zircon-syenite of Norway. (SCHEERER.)

ADAMINE. A mineral obtained from Chanarcillo, in Chili. Some crystals are rose red, others are green and grey, and occasionally white. DAMOUR gives its composition as—

As^2O^5	39·24
ZnO	40·11
CuO	1·75
H^2O	4·25

ADANSONIA DIGITATA. (Vol. i. p. 28.) See BAOBAB.

ADANSONIA FIBRE. The fibre of the Baobab used for paper-making. See BAOBAB.

ADIPIC *Series of Acids.* $C^nH^{2n}O^2 = C^n - {}^1H^{2n} - 1CO^2H$. These fatty acids are distinguished by a high degree of stability. Even some of the highest members of the series—as Palmitic, Stearic, and Cerotic acids—may be distilled without alteration, and they all, with the exception of Formic acid, offer considerable resistance to the action of oxidising agents. See FATTY ACIDS, and the organic acids under their respective names.

AESCULIN or **ESCULIN.** A fluorescent substance, obtained from the white inner bark of the horse chestnut (*Aesculus hippocastanum*). The aqueous solution is highly fluorescent. An infusion of the horse-chestnut bark exhibits the same phenomenon. The composition of aesculin is usually given as $C^{30}H^{16}O^9$. See WATTS's *Dictionary of Chemistry.*

AGARIC, AMADOU. (*Der Baumschwamm*, Ger.) (See AGARICUS, vol. i. p. 32.) Recent researches have shown that some agarics contain mannite, others mycose; others contain peculiar kinds of sugar, amongst others one the character of which has not been determined. Species very closely allied, growing on the same soil, contain sometimes mannite and sometimes trehalose.

The *Agaricus fœtens*, according to TACI, contains mannite, water, pectic acid, fibrin, [illegible], ligneous and colouring matter.

The *Boletus Laricis* (Larch agaric) contains agaric resin—a red-brown substance, soluble in alcohol, wood spirit, &c.—and agaricic acid, which crystallises in tufts of needles.

AGRICULTURAL MECHANICS. The development of machinery in agriculture has been very marked during the last quarter of a century. There are several causes for this. The repeal of the Corn Laws rendered it necessary that every appliance should be made use of for cheapening production. The same cause increased the demand for labourers in our towns, and gradually agricultural labour, before abundant, became scarce. Considerable emigration also tended towards the same direction, until at the present time machinery is a necessity, and without mechanical aid work could not be done. It has been said, we think unjustly, that England is not an inventive so much as an improving country, that whilst we are very ready to take up designs of others and increase their practical value, we are not original, and design but little. That this was true as relating to agricultural mechanics—or rather appeared to be so—we do not deny. Previous to the time we have named very little was done. It is true that a correct form had been given to the mould board of the plough. The drill and horse-hoe had been invented, and fixed engines and threshing

machines were beginning to be used. In Scotland progress had been greater. The threshing machine was a reality there when comparatively unknown with us. Now we are convinced that inventive activity depends upon demand. The reason why we were regarded as deficient in invention is to be found in the fact that labour was plentiful, consequently there was no pressing demand. In Scotland, the population being much smaller than with us, and agricultural labour being consequently scarcer, the employment of machinery was more general. Now, however, the tables are turned. English machinery is superior to that of Scotland, and, indeed, we hold a world-wide reputation. Not half, or even a quarter, of the machinery made in this country is required for the home market. Many of our leading firms have agents all over the Continent, and a large portion of their manufactures go abroad. Indeed, not the least remarkable feature of the activity we have alluded to is the extraordinary foreign trade which has sprung up.

The most prominent fact has been the practical application of steam-power to the cultivation of the soil: and the enthusiast in former times was right who felt that the power which can drive the ship through the waves, and sends the train tearing along the rails, must be applicable to the slower operations of breaking up the soil. To the late JOHN FOWLER is due the merit of first bringing the subject into a practical form. Mr. WILLIAM SMITH, of Woolston, was an early inventor, but it is quite certain that the first set of machinery he possessed was made by FOWLER. Both are deserving of great credit for their exertions. In the year 1859 Mr. JOHN ALGERNON CLARKE, the able editor of the *Chamber of Agriculture Journal*, reviewed, in a prize essay of the Royal Agricultural Society, the history of steam culture to that date. Up to that period two distinct opinions prevailed as to the correct principle. One party held that the power should travel on the surface, being connected with the implement; and an offshoot from this theory was the carrying of the machinery on permanent rails. The other and more practicable view was, conveying the power from a fixed point or from a movable point on the headland by means of a wire rope. Under one or other of these heads are included all the hundreds of inventions which have been registered or patented. With regard to the traction view, it soon became evident that the weight of the machinery acting on a more or less softened surface would not only press into the soil, but would require a great portion of the power to cause locomotion, and but little would remain for efficient cultivation. As long as the surface was hard and dry—as on stubbles in a dry autumn—a traction engine might travel with comparative ease, and propel a cultivating implement which might so comminute the surface as to prepare a seed-bed at one operation.

The first man who brought out a machine capable of actual work was a Mr. JAMES USHER, of Edinburgh. His invention comprised a portable steam-engine, mounted on a framework, mainly supported by a pair of broad fellow-wheels behind, and a front pair of wheels turning in a transom for steerage. On a transverse shaft behind, driven by toothed gearing, and capable of being raised or lowered, were fixed four or more discs or plates, each carrying three ploughs of a curved form, so arranged that no two shares should strike the ground at the same moment. The resistance of the soil was to form the motive power, all the power of the engine being concentrated on the revolution of the shaft. Mr. CLARKE states that the first machine built by Mr. SLIGHT, of Leith Walk, Edinburgh, was successfully tried during the autumn of 1851 and spring of 1852, and says it is certain that the propelling action of the rotatory tillers not only enabled it to mount inclinations which it could not cope with by the mere adhesion of the broad roller upon which it travelled, but that no part of the motive power was engaged in effecting the onward motion. Professor WILSON spoke favourably of the trials at Niddry Main, near Edinburgh, in February 1852. Further improvements were afterwards made, reducing the weight from $6\frac{1}{2}$ to $5\frac{1}{2}$ tons, and a company was formed to carry out the scheme, which in practical work doubtless proved unsuccessful. The travelling over land already disturbed would be a difficult and laborious process, and it is probable that wear and tear and breakage were excessive. At any rate, the scheme was abandoned.

A Canadian, Mr. R. ROMAINE, patented a steam cultivator in 1853, which was tried by Mr. MECHI, and not successfully. Here horses were associated with steam; the former drew the apparatus, whilst the power was employed to rotate the diggers.

The importance of thorough pulverisation of the soil induced Mr. W. C. WREN HOSKYNS, M.P., to patent his idea of a steam rasp. In all these schemes the assistance that could be rendered by Nature was forgotten, and, in attempting to anticipate her work, they naturally failed. Reducing a solid wedge of clay to a condition of powder might be possible if the clay were thoroughly dry, although the power required would be enormous; but when the clay was moist, such operations would be impracticable. And so, one after another, such schemes came to an untimely end.

B 2

In the year 1858 M. T. RICKETT's steam cultivator was tried at the Royal Meeting at Chester, and, operating on a sandstone soil in a dry condition, made a successful trial. This consisted of a revolving digger attached to the tail of a locomotive engine. The tiller revolving in the opposite direction to that in Mr. USHER's invention, absorbs more power, but as the soil was raised up in front of the axle and carried over by the tines, more thorough pulverisation resulted. There were several ingenious arrangements, but like its predecessors, this machine was never available for practical purposes. All these inventions combined the power and the implement in one frame. The next application we notice is BOYDELL's traction engine with endless rails. The principle was that the wheel, instead of resting on the ground, formed a broad causeway, caused by the rail-pieces being upon the circumference of the wheel, which forms a continuous line of rails, over which the wheel revolved. Ploughs or cultivators could be attached behind. The Government made use of this engine to move artillery over boggy ground, and for a time successfully, but the injury resulting from wear and tear was excessive. Nor must we omit a short notice of Lieutenant HALKETT's guide-way system of cultivation, which consisted in laying down light rails at 30 ft. gauge, and carrying the cultivating implements on a frame, which supported the motive power communicated through a number of wheels, thus distributing weight over space. In our young days we had frequent opportunities of seeing the attempts to bring this system into a practical shape. Lieutenant HALKETT hired some land near London, and constructed his machinery; as far as we remember, the wheels supporting the frame were either 16 or 32. These were driven from a fixed engine, which occupied one side of the frame, and the implements of husbandry were arranged underneath. As it would have been impossible to work so great a width at once, save for some very light operation, the ploughs were made not only turnrest, so as to work in any direction, but also to slide across the frame, and so take consecutive bouts. Hoes were in like manner attached, and the workman was enabled to sit at his work, which was a curious arrangement, but nevertheless possible to carry out.

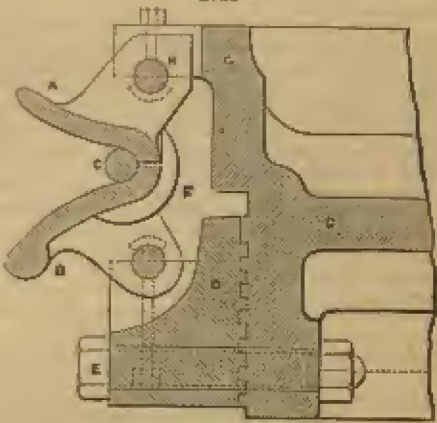
It was proposed to carry water in a dry time, and by pipes and hose distribute it on the surface. When a stretch of land had been duly worked, the vast machine was to be shifted by means of transverse rails on the headland. There was much ingenuity in the scheme, but cost and complication condemned it. It was utterly beyond the reach of the tenant, and no landlord or company could be found sufficiently sanguine to take it up. Lieutenant HALKETT's principle minus the fixed rails, was adopted by Mr. GRANTHAM, C.E., who carried the rails attached to the wheels, but like the original this invention did not succeed. It soon became evident to the merest tyro in steam culture that the weight of the engine, and the consequent power absorbed in its locomotion over soft ground, were insuperable objections to any scheme in which the engine drew the implements over the land. BOYDELL, COLLINSON HALL, USHER and ROMAINE, are now almost forgotten, and the steam rasp of Mr. WREN HOSKYNS never took form. For many years the principle of hauling the implements to and fro by a wire rope has been adopted. Originally the engine was stationary, the rope being wound upon or unwound from windlasses, set in motion either by straps, or universal joint. This system, which is still practised, is known as the *roundabout*, because the wire rope is carried round the headland. The implement commences to work at the furthest point, movable anchors on opposite headlands conduct the rope by travelling round a fluted wheel or sheave in the proper direction. This was the original form in which FOWLER's invention appeared. Mr. W. SMITH, whose apparatus was afterwards improved upon by Messrs. HOWARDS of Bedford, used claw anchors, which were shifted as required by manual labour. Messrs. FOWLER and Co. soon made a material improvement in their machinery, viz. combining the engine and windlass, and making the combination draw itself along one headland, whilst the anchor travelled in a similar direction on the other.

As this plan is still employed occasionally, it may be shortly described. The main feature consists in the clip drum windlass, placed under the boiler in a horizontal position. Instead of coiling on a barrel, the rope is gripped by a series of pairs of gripping pieces or clips, which are self-acting: the force with which they hold the rope being in proportion to the tension or strain upon it. The advantages of this arrangement are manifest. The implement is drawn to and fro by an endless rope travelling round the clip drum and the anchor sheave; less rope is required, the strain on the rope is steady and equal, and we get our power employed with the minimum waste. This was tested at the trials in 1864, when a prize was offered for the best windlass and application thereto. We are indebted to Mr. CLARKE's report of the Wolverhampton trials for the following illustration (*fig.* 2165), showing a section of the clip drum, and the mode in which the jaws or clips operate on the rope.

A and B are one pair of the clips which surround the entire circumference of the drum; the upper clip, A, hinged or centred upon the main flange, C C, and the lower

clip, B, upon a ring, D, which is screwed upon the flange or body of the drum by a thread chased round its periphery. Thus, by slipping the ring, D, part of a revolution upon the drum, it is gradually shifted a slight distance higher or lower, with the effect of diminishing or increasing the space between the centres of all the upper and lower clips simultaneously. The ring, D, is held in a required place upon the drum, by means of bolts, E. By this power of regulation, the distance between the centres of each pair of clips admits of regulation according to the diameter of the rope, a most important adjustment to suit a wearing rope. It will be seen that upon the rope leaving the jaws, the pieces open outwards, the lower clip, B, being formed with a weighted lip for the purpose of falling open, and at the same time raising the upper clip, A, by means of the tongue, F. The extent of opening is limited by the stop, H, coming against the drum flange. Not only was this adjustment to regulate the opening of the jaws necessary on account of the wearing of the rope, but also owing to the gradual wearing away of the clips themselves, which is considerable.

2105



It has never been actually proved as to the comparative friction of the clip drum or a windlass with the best coiling gear. On the whole, we are inclined to think that rope lasts longer when coiled. The hug of the clip drum must be very trying. In the clip drum system we have an endless rope, the two ends being attached to the implement. Were there no provision for lengthening or shortening the rope, only one size of field could be worked; consequently, in the frame of the implement are two small drums, each capable of carrying the necessary additional amount of rope that may be required. But this is not all. In order that the clip drum may work properly, that no undue friction occurs, it is necessary that the tail rope should be kept at a certain tautness. Slack rope is very objectionable. To meet this difficulty a taking-up gear is attached to these drums, which is both ingenious and effective. The drums are connected with each other by pitch chains, spike wheels, and ratchet clutches in such a manner, that the pulley rope, uncoiling from one barrel, causes the other barrel to rotate, and to wind in tail rope at five times the speed. The smaller spike wheels are thrown in and out of gear with their respective barrels by levers and rods connected with the ploughman's two seats at the opposite ends of the implement; so that the act of the man's seating himself reverses the gear of the barrels, and prevents the strain on the pulley rope, to wind in the slack or following rope until the tension of the latter becomes one-fifth that of the former. We do not think an illustration necessary, because ingenious and effective as this mechanism is, it is now seldom used, both it and the clip drum being to a great degree superseded by the double engines which, first shown by Messrs. Fowler at Worcester in 1863, have been greatly improved, and at present comprise by far the most important feature of their extensive trade. This firm was not the first to adopt the double-engine system. At the same show Messrs. Savory and Son of Gloucester exhibited engines, in which the boilers were encased by revolving drums, the latter supported by three pairs of friction rollers fixed in brackets on the boiler; motion was given by a long crank shaft inside the drum by pinions and internal gear. The coiling of the rope on the drum was regulated by means of guide rollers travelling along a rotating threaded shaft, which acted perfectly, the wire rope never getting lapped or injured.

The successful trial of these engines brought them into favourable notice both at Worcester and Newcastle, where they appeared for the second and last time. We conclude that, practically, they did not answer, as shown at Worcester, a higher speed was necessary for economical running than would be prudent without reducing gear. They appeared to work steadily, but more time was lost in slackening and starting than with Fowler's engines, in which a horizontal drum revolves under the boiler, the rope being regularly coiled by the action of self-acting guide pulleys, which

must be explained further on. Messrs. Fowler made some extraordinary work, digging low at least twelve inches deep.

About this period great activity was exhibited by manufacturers. The Royal Agricultural Society feeling the importance of the subject, made steam cultivation the principal feature of their highly successful show at Newcastle-on-Tyne, and it was generally considered that those trials took rank as the most valuable and important held up to that time. Great pains were taken to get satisfactory results, a large area of land was cultivated, systems were tested by having to execute a given quantity of work. Draft and power were calculated, and yet the prize machinery was abandoned in two or three years, being found unsuitable for any but highly trained workmen. The idea which was thrown out at Worcester that both engines should work simultaneously, was seized upon by Fowler, who produced his Newcastle seven-horse power engines, fitted with clip drums, and so arranged that they worked together. We reproduce an extract from the Judges' Report:—

'On Lot 2, Fowler worked two seven-horse cylinder engines, acting simultaneously on opposite headlands. The engines are fitted with clip drums, reversing gear, &c. *This arrangement of power was the novelty of the show.* At Worcester double engines were first exhibited alternately in action. It was suggested that a great improvement would result if the engines could be made to work together. This was then considered impracticable, and yet in one short year we have the idea matured. A great step has been taken in the way of steam cultivation, which may fully be claimed as the result of that prize system which has been in some quarters so rashly and sweepingly condemned. And how has this been brought about? By a simple and apparently insignificant alteration in details: formerly the joints which connect the different lengths of rope could not travel round the clip drum. The friction pulleys (which hold the rope up to the clips) being fixed in a certain position would cause an obstruction and consequent fracture. The four-hundred yard rope worked round the clip drum; the joints travelled round the anchor sheave, and the length of furrow could not exceed about 350 yards. These pulleys are now hung upon an upright axis, and have a free motion which allows them to give way when a joint passes. They are brought back to their position by the action of an india-rubber spring which connects them together, and which is strong enough to keep the pulleys properly pressing on the rope. This arrangement worked admirably; and during the two days' trials to which these engines were subjected, we never found that the rope exhibited any tendency to slip, so perfect was the grip of the clip drum.'

Such was the deliberate opinion of the judges after a careful trial, fully endorsed by the public who witnessed the splendid and automatic-like work of these two engines, as they drew the cultivator to and fro at great speed. So satisfied was one of the stewards that he forthwith ordered the Newcastle set. Why then was it a failure? Simply because it was found impossible to get drivers equal to the work, the utmost exactitude being required. If one engine started or stopped before the other, the other would pull not the implement only, but the opposite engine also. What looked easy enough by the aid of signals, was practically impossible, and so the Newcastle engines were relegated to limbo, where so many more bright designs have been consigned. Mr. David Greig, one of the active partners in the Leeds works, turned his attention to perfecting the double engines, and his success has been great and deserved. Although clip drums and anchors are still made, most of the work both for home and foreign trade consists of double sets. It would be beyond the limits of this article to detail the various improvements made from time to time, by substituting steel for iron whenever it was practicable, by improved driving gear, and more perfect coiling and slack rope arrangements. The single cylinder engines are very admirable. We propose to describe the windlass and coiling gear, and the mode by which locomotion is effected. It is needless to say, that strength with lightness has been studied throughout, and that no pains have been spared to secure a really efficient and durable apparatus. The horizontal drum is placed under the boiler and turns upon a central stud. It comprises a roll and two flanges, above the upper of which is cast the teeth gearing, through which a pinion on the upright shaft communicates motion, the shaft being itself driven by a pair of bevel wheels from the crank shaft. When the windlass is out of gear, the slack rope is kept from paying out too fast, and thus causing extra work by means of a simple friction strap, which is pressed upon by a ratchet, as shown and described below.

We are again indebted to Mr. Algernon Clarke's excellent report of the Wolverhampton trials for our illustration (*fig.* 2166) and description of the rope drum and coiling gear:—'The stud, B, which carries the rope drum is connected by six bolts, A A, with a plate riveted to the outer shell of the boiler. The lever, C, carrying the

guide pulleys, is attached by a joint or hinge, D, to a bracket, E, which swivels round the drum stud or centre, B, so as to allow of the wire rope being run off and on without bend at very considerable angles with the direction travelled by the engine on the headland. The correct coiling of the rope—a very important point as regards its durability—is effected by the guide pulley, C, having a slow, vertical, reciprocating motion imparted to it by a pin or die, M, traversing in the inclined groove of a very slowly revolving cam wheel, placed under the drum, and ingeniously worked by a train of differential wheels. The spur wheel, J, which is fast upon the cam and the spur wheel, K, which is fixed upon the stud, B, are of equal magnitude, with the same number of teeth, and engaging with them are two pinions, G and I, cast in one piece, but the upper one having one tooth more than the lower one. These pinions are hung upon a stud pin attached to and carried round by the rotation of the rope drum, so that the pinions are continually rolling around the spur wheels; and the result of the variation in cogging is that, as the spur wheel, K, is a fixture, every time the pinions perform one circuit they cause the spur wheel, J (and therefore the cam to which it is attached), to turn to the extent of one tooth. This slow motion of the cam gradually raises the die or pin of the lever, C, in the inclined groove or thread—this groove raising the lever during one semi-revolution of the cam and depressing it during the other. The dotted lines indicate the lowest revolution of the lever. The movement is so timed that the cam lifts or sinks the guide rollers, three-fourths of an inch, or whatever may be the one thickness of the rope, for each revolution of the rope drum, and the range and direction of the guide rollers thus coincide at all times with the progress either of coiling or unwinding. The rope when running out is kept partially taut, and the revolution of the out-of-gear drum restricted by means of a simple friction strap, L, and ratchet pall, M, which ceases to act upon the strap when the drum rotates in the opposite direction for winding up the rope.'

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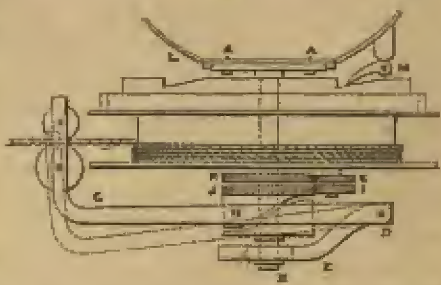

We offer no apology for this long extract because it would be impossible to explain this ingenious and complicated motion in more fitting language. Formerly, the gearing wheel of the windlass was a portion of the rope drum casting; consequently, when the teeth were broken either from accident or from being worn out, a new drum was required at a cost of from 18*l.* to 20*l.* Latterly, the toothed wheel has been made separately, and bolted on, and in case of renewal the outlay is much reduced, a new rim costing under 5*l.* This is a great improvement, and with other minor alterations, we have a very perfect engine. Two novelties may be noticed. The first has reference to the road gear. In steam-plough engines and ordinary agricultural locomotives the driving wheels are generally made loose on the axle. Immediately inside each is a disc keyed on to the axle, in which are seven or eight holes, and one corresponding hole in the boss of each wheel. A pin is slipped into the wheel, and passes through any one of the holes in the disc, by which arrangement the relative movement of the driving wheels and shaft are the same. On turning a sharp corner the pin of the inside wheel is removed, consequently all the driving is done by the exterior wheel, and the engine turns quickly round, the loosened wheel being almost stationary. For the above-mentioned engines this plan, though clumsy, is simple and the best; but for engines that have much road work, and consequently are required to steer handily, an arrangement, invented by Mr. Roberts, and used in spinning machinery, called the Jack-in-the-box, or differential motion, has been most successfully applied, to compensate for the difference of motion required between the driving wheels. It is a beautiful though most puzzling train of wheel work, and many a good mechanic has failed to understand it at once.

Our illustration (*fig.* 2167) and description, from the pen of Mr. Robert Neville, will, we hope, make the matter comprehensible:—A is the countershaft of a traction engine, driving a spur wheel, B, which is loose on the main axle, C. B has in it two bevel pinions, D D, in which gear two bevel wheels, E and F. E is keyed into the shaft, C, as is also the driving wheel, G; hence the relative motion of E and G are the same. The other bevel wheel, F, is rigidly connected with the driving wheel, H, which is loose on the shaft, C. When the strains on the wheels, G and H, are equal, no dif-

ferential motion takes place, and both wheels drive equally; but immediately such is not the case, the bevel pinions, D D, come into play, and the motion required is at once set up. At times in practice it is convenient to dispense with this motion, and make both drawing wheels act together. A pin, therefore, is used, which slips into a hole in the boss of H, and passes through B and F, thus locking all together. Mr. NEVILLE has also favoured us with a sketch and description of Messrs. AVELING's improvement in the method of carrying the crank, intermediate shafts, and driving axles of road locomotives (*fig.* 2168). This consists principally in the elongation of the side plates of the fire-box end of the boiler, thus distributing the strain, diminishing the weight, and avoiding leaks and breakages so common in the old type of engines with cast-iron brackets. The centres of the shafts being all in one plate, they cannot alter their relative distances. The upper part of each side plate is stiffened internally by curved plates fixed to the top of the boiler, between which and the outside plate the crank shaft plummer blocks are bolted.

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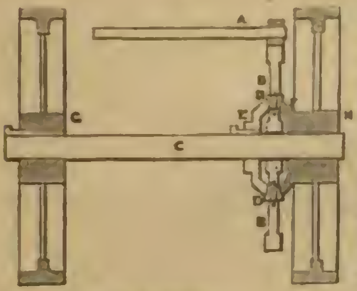
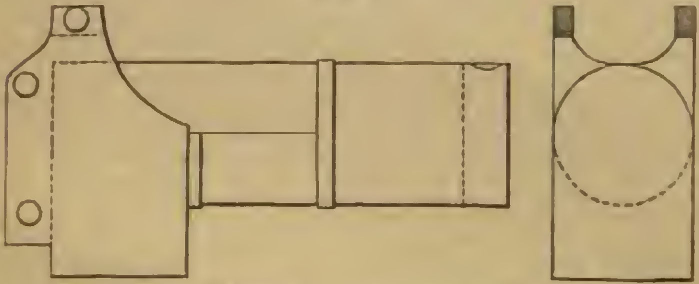


Compensating Gear.

2168



Elevation

End View

Road Locomotive Boiler with Wrought-iron Brackets.

Double engines are constructed from 6- to 20-horse power. The former, which constitute a cheap set, were introduced three or four years since for light land, in order to meet and compete against the improvements effected in roundabout systems, which will be shortly described. These small engines are marvels of power, and we can imagine them a great success for light land, and highly suitable for large occupations, where there is plenty of work—threshing and hauling—during the winter. For these engines, by removing the drums and reversing the fore carriages, become traction engines, suitable for all sorts of farm work. The most generally useful engines, especially for the objects of hire, are the single cylinder 14-horse power nominal, capable of working to nearly double that pressure. Occasionally 20-horse power engines are made, but, except farms are specially laid out with good roads, the weight is too great for headlands, and they are unable to travel when the land becomes at all sticky.

Although Messrs. FOWLER make if required *roundabout tackle*, and have lately introduced a horizontal windlass, with coiling gear, and a semi-automatic anchor, it cannot be said that they make such a speciality as is the case with Messrs. J. and F. HOWARD, BARFORD and PERKINS, and the Company recently established to manufacture FISKEN's patents. It is only justice to the energetic tenant of Woolston, Mr. WILLIAM SMITH, to state that, although not the originator, he has been the promoter and untiring advocate of roundabout cultivation, his own admirable operations being the best possible testimonial to the value of such systems properly carried out. The Bedford firm got their first initiation into the work by being employed to manufacture SMITH's tackle. BARFORD and PERKINS for a long time, and possibly even now, furnish the Woolston Grubber with their machinery; and the FISKEN system, though very different in details, starts with a fixed power and movable anchors, which so far agrees

with the original principle. Messrs. Howard have tried their hands at double engines and traction engines, with windlass attached and separate; but their success in connection with steam culture has hitherto been principally associated with a fixed engine driving a separate windlass, and working an implement formerly through the medium of a double snatch block and claw anchors, and latterly by automatic anchors of a highly ingenious description.

We propose shortly to describe their most modern improvements. The original apparatus required five men, in addition to porter-boys. Now an engine-driver and man on the implement complete the necessary labour, which is of great importance when it is remembered that steam culture is often most valuable at those seasons when manual labour is most in demand, as at hay time, harvest, or the hoeing season. The engine, whether fitted with traction gearing or only portable, is stationary, and drives the windlasses by a universal joint, the latter being so placed in relation to the fire box that the engine-driver can reverse the drums by means of a lever rod without leaving his position on the engine. The clutch gearing is so arranged that it is impossible for both drums to be at work at the same time. The winding drums are hung vertically on a horizontal axis, and are made to traverse a prescribed distance backwards and forwards by means of a double helix or cam cut in the shaft, a pin attached to the drums, and working in the helix, and differential wheels. This is very simple and efficient, the rope winding with great regularity. A brake working in a clutch on the side of the windlass prevents the too rapid discharge of tail-rope, and the rope is guided both in drawing in and paying out by two grooved friction pulleys fixed to the frame. The anchors, which are placed on opposite headlands, are moved forwards by the pressure of the hauling rope, and are perfectly automatic. The anchor consists of a rectangular iron frame, supported on four strong disc wheels. In the centre of the off-side of the frame, and midway before the fore and hind wheels, and just opposite the rope sheaf, is a small vertical drum, capable of carrying 100 yards of rope, the end of which is fixed to a dead anchor behind the machine. A pitched chain gear is fixed on the inner side of the vertical drum, and carries a pitch chain, which runs over a small, smooth, and adjustable pulley fixed at the hind part of the frame. A hook is attached to this pitch chain, and this hook, coming in contact with a stop bar, at once arrests the traverse of the pitch chain, and locks the drum. It will be evident that if the bar is drawn back so that the hook is released, the strain of the ploughing rope on the anchor sheave will cause a quantity of headland rope to be unwound, and the forward motion of the anchor will ensue, provided the pressure of the ploughing rope is sufficient to overcome the resistance of the soil. The pitch chain is allowed to make one revolution, until the aforesaid hook comes once

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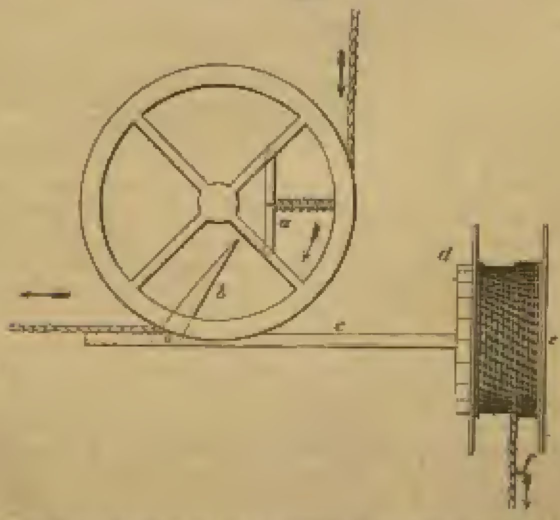

more in contact with the bolt stop, and consequently the distance traversed at each bout of the implement depends upon the length of the pitch chain, which can be increased or diminished by altering the position of the small pulley round which it runs, and

taking up or letting out links. Thus the traverse of the anchor is regulated according to the width of implement that is used.

All that remains to explain is how the stop-bolt is drawn back and replaced. This can but be done by the aid of the diagram (*fig.* 2169), which shows a plan of the sheaf wheel, stop bar, headland rope, pulley, &c. The pitch chain is represented as locked. The implement has just reached the headland, and is about to commence its return journey. The first effect of the straining rope, by causing the sheaf to revolve in the direction indicated, brings the friction pulley, *a*, into contact with the lever fork, *b*, attached to the lock bar, which is consequently drawn back, liberating the pitch chain, and the tension of the dead anchor rope causes the drum to let out sufficient rope to allow the anchor to traverse the necessary distance. The first effect of the strain of the hauling rope, when the implement is being drawn towards the anchor, is to replace the lock bar in position. The anchor commences to travel, being actuated by the pressure of the hauling rope on the sheave, and no longer held back by the dead anchor, until further motion is prevented by the hook on the pitch chain meeting with and closing on the stop bar. The spring pulley, passing over the lever fork, causes a little click, the friction being too slight to have any wearing effect. Of course, this depends on the tension of the springs, shown at *a*, which should be very light. The anchor is thus perfectly automatic; all that the ploughman has to do is to adjust the steerage from time to time according to inequalities in the headland. The objection to this, and all other anchors dependent for progression upon the strain of the hauling rope, arises from the fact that when the land is light and the obstruction, therefore, to the movement of the implement at the minimum, it occasionally happens that the pressure of the rope is not sufficient to overcome the weight of the anchor and the resistance from friction on the disc wheels, and the implement travels whilst the anchor remains stationary. We do not think this difficulty is of frequent occurrence. When it occurs, the anchor must be unloaded and made as light as possible, and something can be done in the way of assisting by cutting trenches for the disc wheels to travel in.

Messrs. Barford and Perkins of Peterborough occupy a prominent position as manufacturers of cheap roundabout tackle, which may be considered their speciality, as they have never attempted double engines. Their idea in devoting attention to the subject was that however admirable the action of double engines might be, the heavy outlay and the absence of sufficient area to render such outlay profitable, would prevent their adoption by the majority of occupiers, whereas if a cheap system could be devised which could be worked by an ordinary portable engine, steam culture might be open to all. The result is a very practical application, comprising a single cylinder engine of the ordinary type, and of eight- or ten-horse power. The last time we carefully studied details, viz. at the Chester show of the Manchester and Liverpool Society in the autumn of 1873, an eight-horse power engine of Messrs. Clayton and Shuttleworth's was employed. The windlasses which are placed in front are driven by pitch chain gearing, which when properly made and working with considerable play, is found very superior to a strap, and more adjustable than a shaft or universal joint. The speed is regulated according to the nature of the land, by the proportionate dimensions of the pulleys on the engine and windlass. Thus, for strong land where a slow speed is desirable, the driving pulley attached to the crank shaft on the opposite side to the fly wheel is 13 in. in diameter, whereas the pulley on the shaft of the windlass frame is 18 in.; whereas for light soils uniform pulleys of the larger size are adopted. It was at first thought that considerable loss of power would result from the use of the pitch chain, but experience has proved that when kept sufficiently loose this is not so; possibly there may be additional wear on the shaft bearings, owing to the weight of the chain. But this is not a serious matter, and we have reason to believe that this application is satisfactory.

In order to economise labour, and allow of one man attending to both the windlass and engine, a light endless hempen rope passes round the engine and windlass, carried on friction pulleys, and terminating at the valve handle of the boiler, so that the attendant, by pulling the rope either to right or left, can shut off or turn on steam without leaving the windlass, where his presence is required to throw either windlass in or out of gear. This ingenious contrivance will be more clearly and readily understood by reference to the subjoined plan (*fig.* 2170):—

a a a a a a represents the rope attached to the steam valve handle. The windlass frame of iron is carried on four wheels. The bracket, carrying the drum spindle, consists of a strong casting fitted with gun-metal bushes. The drums are hung vertically. The friction brake to check the delivery of slack is simple and efficacious, comprising a lever acting on a flange 3 in. wide. The brake is formed out of eight blocks of wood fastened to a strong iron hoop, and acting on about one-third of the under surface of the drum flange. The drawing (*fig.* 2170) will give an idea of this truly simple and efficient apparatus. *a* is the lever handle, *b* the weight, which can

be shifted along the handle according to the amount of pressure required. c is the break band. When pressure is required, the lever handle is released by removing a

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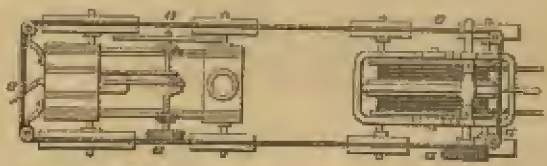

supporting pin, shown at d; the weight causes it to descend, thereby bringing up the blocks against the flange, and thus any amount of pressure is secured. In practice

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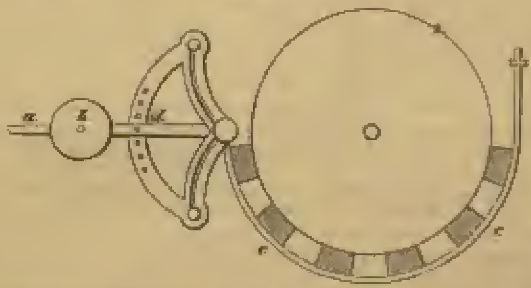

this simple arrangement works admirably; all that the attendant has to do is to take up the lever handle and fix it at the proper point when the drum is hauling, and to set the lever free to act upon the drum, which is paying out.

Messrs. Barford and Perkins manufacture and employ an improved form of Campain's anchors, of which the following illustration, by Mr. J. A. Clarke, will explain the principle (*fig.* 2172):—

The anchor consists of a strong wooden horizontal frame, mounted on four ordinary anchor discs and rollers, and carrying the rope pulley, *a*, in the front part, which, as will be seen directly, has an important effect in balancing the weight. The hind axle, *c*, is a strong shaft carrying two sets of diamond-pointed tines, four in each set, so arranged that two tines shall be in the ground at once. The axle carries the hind disc wheels, and also a ratchet, marked *d*, into which drops a catch on the under side of the long lever handle, *e*. When this handle is raised so that the catch is above the

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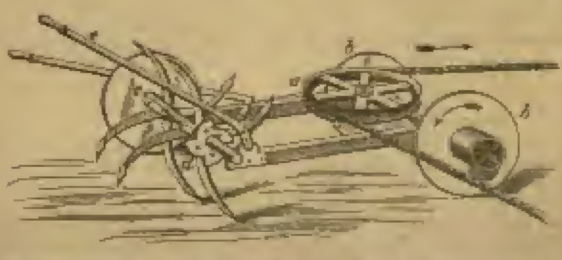

teeth of the ratchet, the strain of the hauling rope tends to draw the anchor along the headland. The tines being embedded in the soil cause the axle to revolve, and the motion continues until the lever catch drops into the ratchet. By placing a pin or bolt in certain holes, the lever can be made to pass over one or more teeth, and so a greater or less distance can be traversed according to the width of implement that is

being used. When the implement reaches the anchor, either the ploughman or the porter-boy, if porters are employed, raises the lever handle, and alters the position of the pins. The anchor, though now released, remains stationary until the implement commences the return journey from the opposite headland: then the strain of the hauling rope effects the operations we have described. The anchors are provided with a weight box in the frame (not shown in the illustration), to be loaded or not according to the resistance of the soil and the proportionate strain on the rope. Such was the anchor up to the spring of 1875; all but automatic, yet not entirely satisfactory, the strain of the rope acting on one side only of the rope pulley, having a tendency to

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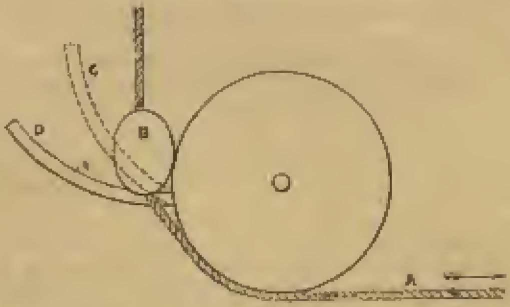

A. The rope. B. Wooden ball. C. Position of lever connected with ratchet hind axle. D. Altered position of lever when affected by the ball, B.

draw the anchor in one direction. Moreover, in light land there was a difficulty in always making the anchor travel. The alteration consists in the introduction of a wooden ball attached to the rope at a certain point. This ball not being able to pass round the sheave, causes the rope to be held fast, and the result is a direct pull on the anchor, which must travel. Moreover, by making the rope pass through a movable guide in front of the anchor, a most powerful means of steerage is obtained, the anchor being able to follow the angles of a zigzag fence if necessary. The ball effects another important object: it actuates a lever, which raises the clutch of the ratchet and liberates the tines by which the anchor is held in position when stationary. The accompanying plan (*fig.* 2173) will explain the action of the ball. A silver medal was awarded at the Taunton Show of the Royal Agricultural Society.

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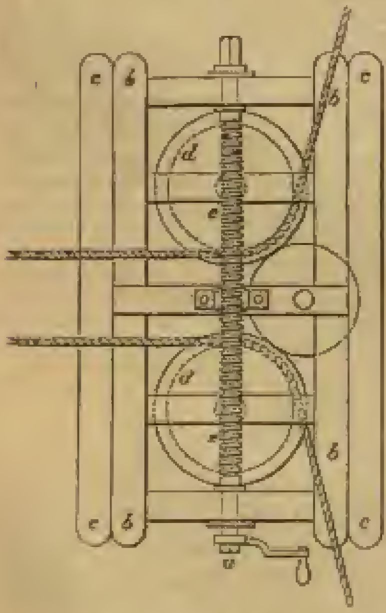

In working the machinery a frame containing a pair of double snatch blocks is fixed about 20 yards in front of the windlass. The frame is of two portions. The inner one, to which the pulleys are attached, is movable by means of a traversing screw. The object of this is to assist in the coiling of the rope on the drums, and prevent the rope leaving the drums at an angle. The annexed figure (2174) gives an idea of this simple and ingenious arrangement. *a* is the traversing screw, actuating the inner frame, *b b b b*, which carries the pulleys, *d d*; *c c c c* is the fixed frame. The two sheaves are 2 ft. $7\frac{1}{2}$ in. in diameter, and the small pulley between

them, which prevents the ropes leaving the grooves, is 8 in. in diameter. One rope turns at right angles towards the anchor on the near headland; the other is carried across the field on porters, or not, according to circumstances, to the opposite anchor.

Messrs. Barford and Perkins recommend that the engine should be fitted both fore and aft with a traversing screw, which allows of the body being shifted within certain limits either to right or left, without altering the position of the wheels, an application which facilitates the fixing of the engine for work. The accompanying sketch (*fig.* 2175) shows the front traversing screw. Enough has been described to give our readers a general idea of the simplicity and efficiency of the inventions of the Peterborough firm, and to show that they have attained their object, viz. to bring steam cultivation in a practical and economical form within reach of the farmer who employs a portable engine.

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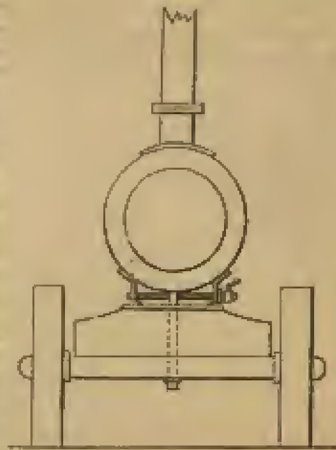

Our notice of steam cultivation machinery in use at the present time would be incomplete, if we omitted to describe what is commonly known from the name of its inventor, as the 'Fisken' system. A name, by the way, that was previously familiar to us as the author of the balance frame, for ploughs and diggers, adopted by Messrs. Fowler and Co. The principle of the 'Fisken' system is the conveyance of the power from the engine by a light rope travelling at a high speed, its transmission to the implement by a reduction of fast to slow speed, through travelling windlasses, and the ordinary wire ropes. This necessitates some complicated arrangements of the windlass. Thus we have the light rope taking a turn round large pulleys, and then again communicating the force so received by gearing wheels, and converting it into a slow motion of the windlasses which draw the implement to and fro between them. The machinery of the windlass is highly ingenious, and capable of being set in motion or arrested, quite independently of the engine which drives the light rope continuously. This is held to be a meritorious feature, as the system is capable of being applied to a fixed engine, or the engine can be set down anywhere that is most convenient, near a pond for instance. And it is quite immaterial whether it is within sight of the work. The windlasses travel forward on the headland as required by the winding in of a headland drum—precisely in the same manner as Fowler's original anchors. The merits or demerits of this system depends upon three points: the durability of the Manilla rope, which travels at from 26 to 35 miles an hour; the comparative loss from friction owing to this

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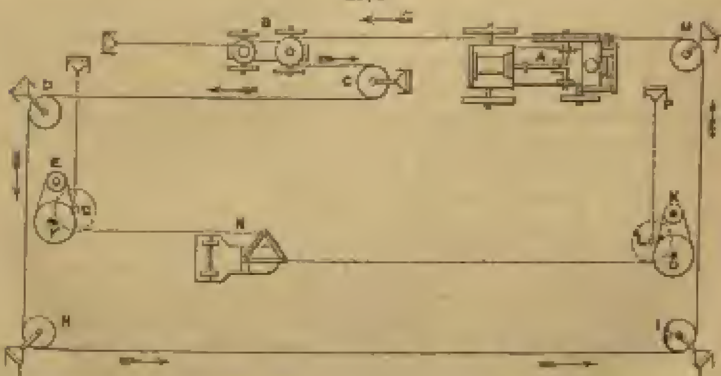
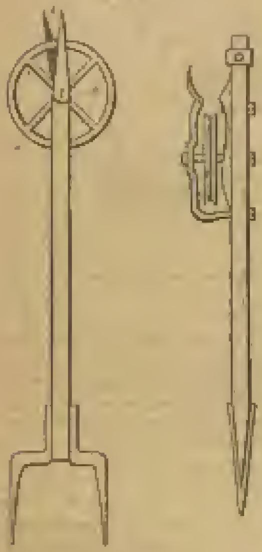


great speed; and the proportion of manual labour employed. That it is highly ingenious requires no argument: that it is capable of doing with the same implements

equally good work as any other system is also abundantly proved, and that the price is not unreasonable. In order to arrive at some conclusion, it will be necessary very briefly to describe the principal features.

The plan of working will be best understood by reference to the foregoing plan (*fig.* 2176). A 10- or 12-horse engine, either portable or traction, is usually employed—fitted with a grooved fly wheel, suitable for reception of a rope ½ or ¾ in. in diameter. The rope is led a three-quarter turn round the fly wheel by means of a small guide pulley which is attached to the fore carriage of the engine, or if the fly wheel is at the reverse end, i.e. over the fire box, it can be attached below. Behind the engine and securely fixed is a tension anchor by which the rope can be tightened or slackened according to weather, &c. The rope is supported on friction pulleys and carried about 3 ft. 9 in. above the ground. These pulleys are attached to strong stakes driven into the ground; they are of two forms as shown (*fig.* 2177).

2177



The angles are turned over large pulleys mounted upon light two-wheel carriages, which are secured by two chains to bars or pegs driven into the ground. As shown in the plan, the endless hemp rope always running in one direction, then takes one turn round the riggers, E and F, of the travelling windlass, G, thence round the corner anchors, at the extremity of the field, and so on to the second windlass, L, where it in like manner takes one turn round the riggers, K and J, and round the corner arches, M, it reaches the fly wheel. The pace is, as has been said, from 28 to 35 miles an hour; so long as the pulleys are properly set and kept well lubricated, the friction is not excessive, as the rope is light; but one could easily imagine serious results both to the rope, and the draft, if the pulley got out of order. The strain upon the rope is very unequal. Thus, whilst the windlass, L, is a gear drawing the implement towards itself by means of a wire rope which is being wound on to a drum, the portion of rope running between the windlass and the engine has nearly all the strain, the tension in the rest of the rope being slight. When the other windlass is at work the strain is distributed over a much larger surface. Whether this inequality would lead to fracture when the rope begins to wear we cannot tell, but it seems probable. As we have said, the windlasses are complicated machines.

The following admirable drawing (*fig.* 2178) is extracted from Mr. CLARKE's report of the Wolverhampton trials:—

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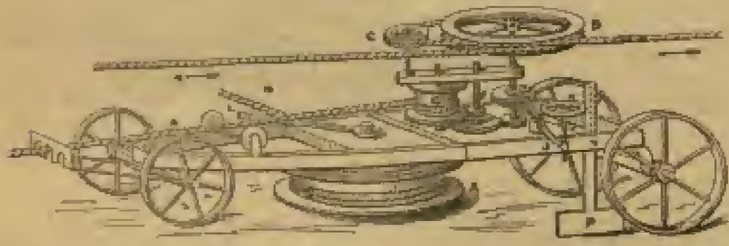
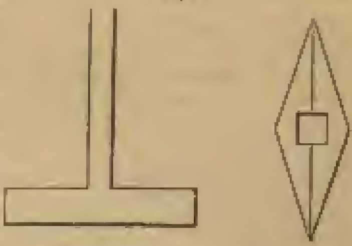


It will be seen that the framework is triangular, carried on 4 wheels, which, however, are not disc shaped, but have ribbed tires. The resistance to side draft is secured by means of a spade fixed in a strong bracket and let down between the hind wheels. The rope drum, A, 4 ft. diameter, is placed under the frame. Motion is communicated from the driving rigger, B, to an intermediate shaft by means of a friction belt acting on a cone, thence to the rope drum by gearing: the intermediate shaft carries two pinions, one of which drives the small drum on which the headland rope is wound. The rope drum, A, is hung upon a stud or shaft which can be turned eccentrically, and thus by means of the lever, L, the drum spur wheel can be

thrown in and out of gear with the pinion on the axis of the intermediate motion. Its motion when paying out rope, however, is restricted by means of a friction strap round the upper flange of the drum; this strap being caught and held by a pall and ratchet which cause the break to operate only when the drum is paying out rope.

2170



Plan of spade. Section.

The action is thus described by Mr. CLARKE:—'Upon the implement arriving nearly at the windlass, the anchor man instantaneously releases the clutch, H, by the hand-wheel, E, and then withdraws the drum out of gear by the lever, L. The other anchor man, at the opposite end of the field, immediately upon finding the rope cease to pass off his windlass, sets the drum in gear and screws his friction clutch tight, and the implement begins its return journey without any delay. The windlass can be moved at any time, being put into motion from the intermediate shaft.' The attendants at the windlasses must be active, intelligent men, and we have four hands employed as against two in HOWARD'S or BARFORD'S systems. Within the last two years—that is, in 1865, a company was formed to work Mr. FISKEN'S patents, of which he was made managing director. We have no information as to results. It must be borne in mind that a considerable time is occupied in shifting from one piece of work to another, principally owing to the necessity of care as to the fixing of the friction pulleys and side anchors.

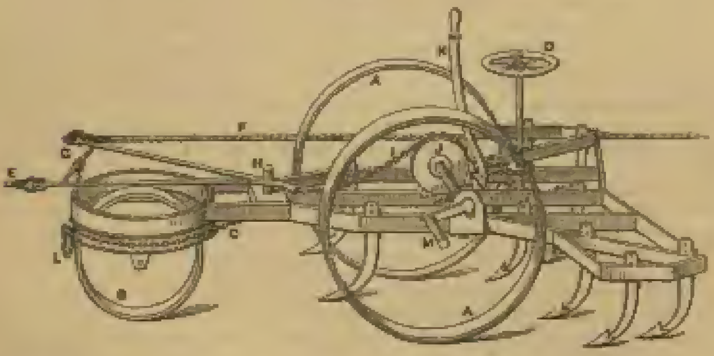
Having thus described some of the more prominent modes of applying the power, a word or two as to the relative advantages. Where farms are extensive, and fields large, and either entirely on the farm or partly by hiring out, something like 1,500 to 2,000 acres of cultivation once over can be effected, the double engines will prove most advantageous. The work will not necessarily cost more to do—and great value should be attached to the saving of time, owing to greater power and efficiency. Where farmers who are on a smaller scale do not care to keep their own tackle, but employ steam tackle on hire, the double-engine system has immense advantages, both in the rapidity with which they can be moved from place to place, the short time required to get to work, and the rapidity with which work can be performed. Much has been said for and against the hiring-out system. It has already been largely tried with varying success: given large fields, tolerably level country, plenty of work, and, above all, good management, sufficient money can be earned to pay a good percentage. Wet seasons are, of course, unfavourable. The great weight of the engines renders them unwieldy on soft headlands. It is a great convenience to the public to have the means of really effective cultivation within reach without the heavy capital required to purchase. An objection is often urged about the difficulty of suiting customers' convenience. We have not found this at all serious. If each double-engine set, say with 14-horse power engine, can average 750*l.* per annum gross earnings, it will pay, with proper management, 15 per cent. on the original cost, of which 10 per cent. should be put by to meet depreciation, which is a heavy item. However beneficial steam cultivation by hire may prove, a large class of farmers will prefer to have their own tackle, so that they can make use of it at the right moment.

The introduction of traction engines, suitable for threshing, grinding, and drawing loads along good farm roads, renders the possession of cultivating machinery still more desirable than when so much time was occupied and so many horses employed to effect a shift. The farmer who occupies 400 acres of arable land requiring deep cultivation should well consider the comparative cost and efficiency of horse- and steam-power; we are quite satisfied that if a wise man the result of his deliberation would be investment in steam under one or other of the forms we have described. We have a word or two to say as to the nature of steam-driven implements. In early days more attention was paid to ploughs and ploughing than at present. The balance plough of FOWLER, with one set of breasts always in the air whilst the others were at work, made and makes excellent work; and if the breasts are removed and open forks substituted, we have a still more efficient digger, with which strong land can be advantageously dealt with in the autumn. Experience has long proved that it is not always or often necessary to invert the surface. The breaking up of the soil to a depth of nine or ten inches by means of a cultivator effects all that is desirable for cleaning operations, and on all soils of a medium or light nature this plan is generally followed. Balance frames are found objectionable in some respects. The weight of the portion suspended tends to equilibrium; and hence we have a jerky motion and

uneven depth, which is especially noticeable in crossing ridge and furrow. Mr. William Smith was the first to invent a cultivator frame which could be turned round at the headland like a horse-driven implement; this was effected by his celebrated turning bow, a very simple arrangement, which he patented and allowed the use of only for a heavy licence. In the year 1869, at the Leicester Show, Messrs. Fowler and Co. received the prize given for an implement best suited for steam culture or a new cultivator, which was afterwards much improved upon, and has long ranked as the most perfect cultivator we have. The principle of this most efficient implement consists in the main axle being cranked and so connected with the rope-attachment in front that when about to turn by the tightening of the hauling rope from the opposite engine, the first effect is to depress the travelling wheels, or in other words raise the cultivator upon the axle, and thereby lift the tines out of the ground by a half turn of the crank. A lever handle within reach of the attendant is at this point brought into connection with the ratchet teeth upon a segment on the axle, and the position of the teeth clear of the ground is secured until the lever is removed, *i.e.* until the implement is fairly turned round and ready for its journey.

The following drawing (*fig.* 2180) and short description is taken from Mr. Clarke's report of the Wolverhampton Show:—

2180



The spokes of the travelling wheels are omitted, as well as the driver's seat. Steering is effected by locking the front wheel, B, either to right or left. This wheel is attached to the frame by means of a ring, fore-carriage turning upon friction balls; it is actuated for steering purposes by means of two chains, C, and a pinion, short upright shaft and hand-wheel, D. The draught ropes are hooked to a large Y-shaped lever, G, connected with the main frame by a strong stud or pivot, H. It may be mentioned that since the Wolverhampton trials it has been found necessary to much strengthen this lever and the portion of the frame on which it plays. The fork, G, is free to move horizontally upon this stud as upon a centre. Whilst the pulling rope holds one end straight, the other arm stands out sideways, leading the tail rope clear of the implement. The short end of the fork behind the foot, H, is attached by a short chain, I, to the segment, J. 'On arriving at the headland the rope, F, begins to pull, producing four successive effects. The fork, G, in being turned at right angles to the implement, first tightens the piece of chain, I; the segment and axle are thus turned part of a revolution, the cultivator is raised upon the axle, and the tines lifted clear out of the ground. Ratchet teeth upon the segment being held by a catch on the lever handle, K, retain the cultivator suspended out of work until the attendant (who has a seat on the back part of the implement, not shown in the drawing) pleases. In the next place the short piece of chain, L, which connects a link sliding along the cross-bar of the fork, G, with the transverse ring of the steering wheel, is tightened, so that the steering wheel is turned in a sideway direction, in readiness for running round the semicircle requisite for turning the implement. The continued pull of the rope, F, then hauls the cultivator end for end, at the same time (owing to the position in advance of the hauling engine) wheeling it round upon fresh ground. And, lastly, the rope, F, having brought the fork piece again to its place over the fore-carriage, draws the implement along its new journey, the rope, E, becoming the tail rope held out by the fork arm in the line of the succeeding course. The return of the fork to its front position loosens the chain, L, leaving the segment free to turn, and to lower the

cultivator when the attendant looses the catch, which he does by pulling the handle, x.'

The whole process occupies only a few seconds, and is effected without the driver leaving his seat, or the missing of land at the headland, which is more or less unavoidable with balance implements. We have described this implement minutely, because it is undoubtedly at the present time that which is most suitable for steam cultivation. The tines can be fitted with different shaped feet, wide or narrow, according to the work, and it will be seen that they are so arranged as to cover the wheel-tracks.

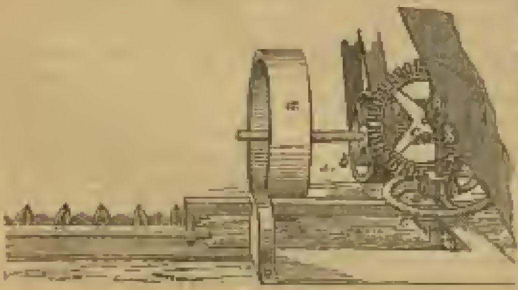
Messrs. HOWARDS have recently introduced a very similar implement, differing slightly in some of its details. In the machine which was shown at Bedford the axle was straight; it is now cranked, and on the inside of the wheel naves are strong ratchet teeth, a clutch being welded in the crank axle. When the implement reaches the land's end, and the strain from the opposite engine or anchor begins to operate, the first effect is to raise the teeth by drawing back the wheel and altering the position of the crank; the second to cause the clutch to fall into a tooth of the ratchet, and so lock the wheel on the side nearest to the rope; the third effect is to cause the cultivator to turn round, the locked wheel acting as a fulcrum. We have not seen this implement at work, and therefore cannot speak positively as to its efficiency.

Reaping machinery was little known before the Great Exhibition of 1851, when two American inventions by McCORMICK and HUSSEY were exhibited. The development of an implement that now occupies thousands of hands in its manufacture is an apt illustration of the influence of demand. Although the Americans have sent us so many inventions in this direction, to them belongs not the credit of origination. Years and years before the time mentioned the Highland and Agricultural Society awarded a premium to the Rev. Mr. BELL, of Carmylie in Forfarshire. This was in 1829, and we believe this machine was working for many years on Mr. BELL's farm, unnoticed by his neighbours, and unappreciated, because up to that time there was no great necessity for either superseding or supplementing manual labour. We have no reliable information as to the question of priority of invention. It is, however, generally supposed that both McCORMICK and HUSSEY owed something to the Scotchman, whose brain alone was responsible for this very excellent invention. So excellent that, in after years, when the old machine was brought to light—taken out of a barn, we believe, where it had lain neglected and well-nigh forgotten—and put into competition with the newer inventions, it beat them all; and was so successful that a well-known firm, Messrs. CROSSKILL and SONS undertook the manufacture of the improved Bell reaper, which in their hands, and that of the Beverley Iron and Wagon Co., is, we believe, continued to this day. If Scotland claims the credit of inventing, it was American enterprise that pushed the trade; and we are certainly largely indebted to that enterprising country for the present advanced position of both reaping and mowing machinery. Those who saw the first American reaper in the Exhibition of 1851, and contrast it with the machinery turned out by such firms as HORNSBY, SAMUELSON, BURGESS and KEY, WOOD and Co., will understand how great has been the progress made. Amongst all the extensive range of agricultural machines, we know of none that have proved so thoroughly successful as reaping and mowing implements. Not only is there a direct saving of money by their use, but the greater expedition with which the work can be done is of immense value: latterly, the scarcity of labour has rendered it imperative to adopt machinery.

We shall very briefly trace the progress of invention to the present time, and then allude to some of the best known machines. The principle in all this class of machinery is that the cutting power, by whatever mechanism, should come originally from the revolution of the travelling wheels, and the farther motions, which have for their object the direction of the corn as it is cut and the removal from the platform to the ground, are derived from the same source. The peculiarities in BELL's machine consisted in the cutting apparatus comprising a dozen or more of large scissors. The upper blades being fixed, the lower moving backwards and forwards, and cutting the stems that came in contact with them. The l[illegible] by which they were attached to the main bar formed the centres in which they moved. The tails of these blades were freely jointed to a movable bar, actuating backwards and forwards. This bar received motion through a connecting link fixed to it at one end, and being attached by the other to a lever, at the opposite end of which were two rollers, running between a revolving cam or oblique fin on a small roller, which was driven from the travelling wheel. The action of the cam caused the reciprocating motion necessary to work the scissors; a strap from another pulley on the same shaft turned a cross shaft at some height from the ground, on which a rigger allowed a cross strap to drive the arms or fans in front, which act an important part, holding the heads of the corn whilst the tail is being cut, and then directing the severed product on to a

travelling platform covered with webbing, by which it was deposited in a continuous swathe on one side. Thus we have three distinct operations, motions for which are obtained from the same source. The cam motion for producing the backward and forward action of the scissors has long given place to a cross shaft and crank, which is much less liable to suffer from friction, and by which a much quicker stroke is obtained. In BELL's machine the horses were harnessed to a pole from behind the machine, consequently they appeared to push instead of pull, although of course in reality they drew from the collar. There is an advantage in this arrangement which is still made use of in the Beverley machines. The reaper faces a crop without preparation; and as the delivery can take place from either side, there is a power of dealing with partially-laid and tangled crops and facing the wind, which is special to this arrangement; where the fields are large and the surface level. The improved Beverley reaper is still in favour, and may be yet seen on the Yorkshire wolds; but the great weight, serious cost, and necessity for the attendant, who cannot ride as in the more modern machines, having to walk hard all day behind his horses, are great objections. Moreover, in the larger machines the width cut is so great that a very heavy swathe results; and where, as is often the case with oats and sometimes with wheat, the corn requires drying before it is tied up, the great mass is not so easily affected by the sun, and if rained upon takes longer to dry than when left in convenient-sized sheaves. We have said that neither of the original American inventions were found so efficient as BELL's reaper. In McCORMICK's machine, which, with its large rake reel and obliquely fixed boards and rigid platform, created such a sensation at the Exhibition, the corn was assisted on to the platform by the sails, and from thence raked off by an attendant, who had a seat provided for the purpose. Thus two men were required, and so far the American invention was not so complete. The great advance was in the arrangements of gearing and the nature of the knife, which consisted of a serrated blade, at first straight, but afterwards waved, and passing through pointed sheaths now called 'fingers.' With regard to the gearing, we reproduce an illustration (*fig.* 2181) given by Mr. J. C. MORTON in his article on reaping machines in the *Cyclopedia of Agriculture*, from which it will be seen that motion was derived from the travelling wheel, *a*, which carried most of the weight. On the same axis was another wheel, *b*, a pulley as to its surface, and destined to drive the rakes by a strap, but cogged on its outside rim, and thereby driving the pinion, *c*, which, by the intervention of a larger wheel, necessary in order to secure the requisite speed, drives a fourth wheel, on the vertical shaft of which was the crank, *e*, which produced the necessary reciprocating motion to the knife. In the cam principle, which actuated BELL's scissors, considerable friction was unavoidable; and, moreover, although it answered for the comparatively slow motion of scissors, would have been useless for a rapidly moving blade.

2181

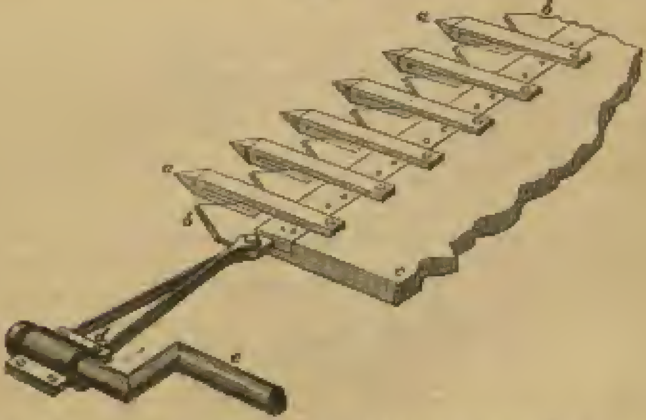


McCORMICK's knife was highly successful, and it was generally allowed that the work was well done. The late Sir H. M. THOMPSON, in his report to the Royal Agricultural Society, speaks as follows:—

'In the report of the implements shown at the Great Exhibition, published in the *Royal Agricultural Society's Journal* for 1851, it was pointed out that McCORMICK's machine had a straight-edged cutter, which had a tendency to press down and pass over the corn instead of cutting it, unless it stood perfectly upright or leaned towards the machine. This was considerably aggravated by its not cutting near enough to the ground. In the McCORMICK's reapers which have come under the reporter's notice this year, the straight cutter has been replaced by one with a scalloped edge, and the machines are also set lower: hence a material improvement is observable in their action—*indeed, the cutting principle leaves little to be desired.* The straight cutter originally used by McCORMICK was entirely dependent on its sickle edge, which enabled it to saw through straw; but the scalloped-edged cutter now introduced consists, in fact, of a series of knives, differing from HUSSEY's in the very different angle at which they work, as well as in having a sickle edge.'

The peculiarity of HUSSEY's reaper consisted in the absence of all mechanism for collecting the corn on to the platform. It comprised only a frame for the cutting apparatus, a seat for the workman, and a platform to receive the corn. The attendant, furnished with a long-handled rake, placed it in front of the ears that were being cut, and pushed the grain on to and off the platform, leaving it in sheaves behind the track of the machine, these having to be removed previous to more work being done. The cutting arrangements demand a short description. The travelling-wheel had ribs on its periphery, giving a better bite; it contained an inner spur wheel, cast separately, and screwed on to its spokes, which, by means of a pinion and bevelled wheels, gave motion to a shaft which ran in the same direction as the machine; a crank on this shaft gave the oscillating motion to the machine. The knife consisted of sections, which met the guards through which they worked at a very acute angle. Hence their great liability to clog, especially when the corn was at all damp. The following drawing explains the nature of the knife, crank, axle, and guards (*fig.* 2182). When the corn was thoroughly dry, nothing could do better than HUSSEY's machine. It was light of draught, having so little lumber; cheap, from the absence of complicated parts, and therefore available for small occupiers. It took wonderfully in the north of England, and was the parent of many useful machines which are to be seen at the present

2182



day, but which are gradually giving way to self-deliverers, principally on account of the labour difficulty. It is a serious evil to have to handle the sheaves twice, which is necessary if the corn is green and contains clover. We all know the advantage of early cutting. Manual-delivery reapers have a tendency to delay operations, in order that this extra work may be avoided. Nevertheless, on small farms where horses are few, and in hilly countries, a light serviceable machine of this kind is still very useful.

Messrs. BURGESS and Co. of London adopted MCCORMICK's machine, and made a great improvement by the introduction of the screw platform. This comprised three rollers placed obliquely across the machine, with a raised screw on each, made to revolve in such a manner that the corn was delivered with great regularity at the side, and left so light and hollow, resting as it did upon the stubble, that the air had free vent under, and even moderate rain did not necessitate the swathe being turned. The action of the screws was further assisted by a cone-shaped divider, also made to revolve. For some years this machine stood out as far superior to any others; the drawbacks were size, which was too wide for ordinary gateways, and weight, necessitating three horses if the land was at all soft. In 1855 Mr. THOMAS PARRINGTON, then residing at Lazenby, Redcar, thus reports:—

'I have cut with it some wheat varying in yield from 32 to 40 bushels per acre, some of it much lodged; also a very heavy crop of oats, so much laid and twisted in some parts that I thought it impossible for any machine to cut them at all. One pair of horses worked the machine from day to day; they have to travel no faster than the ordinary ploughing pace, and a boy of 16 managed them without any difficulty. The machine is so constructed that there is very little wear and tear going on; it delivers the cut corn in a beautiful swathe, laid so straight and lightly on the ground that the sheaves are quickly gathered up; the swathe is evenly cut, and left perfectly

larly clear. I found that the machine will cut from 1¼ to 1½ acre per hour; it is always cutting its full width, viz. 5 ft. 8 in.'

About the year 1860 Messrs. SAMUELSON and Co., of Banbury, who succeeded Mr. GARDINER, whose name was so long known in connection with turnip cutters, turned their attention to reaping machinery, and produced a novelty from America, which was, we believe, the original of all the sheafing machines which are now so generally used. The novelty consisted in the action and position of the rakes; to a vertical shaft driven by gearings from the main axle, two rakes are pivoted or hinged, the direction of these rakes, that is, their orbit, is determined by an iron cam. Small friction rollers bracketed to the under side of the rake shafts travel on this cam, which is so arranged that the rake enters the corn gradually and inclines it towards the platform whilst it is being cut. The platform is quadrant shaped, its radius being the length of the cutting bar, indeed, its shape and dimensions are regulated by the circle described by the rakes, its centre is the same point as that of the vertical shaft. The *modus operandi* is as follows:—As the reaper advances the revolving rakes dip alternately into the standing corn and first incline the grain towards the cutter, then sweep it round the quadrant-shaped platform, and leave the sheaf on the ground some 5 ft. from the standing grain; owing to the form of the rakes and the action of the cam, the butt end of the sheaf is somewhat fanned out; indeed, when the corn stands well, nothing can be better than the delivery of the sheaves, which are laid at distances of 11 ft. 6 in. from each other. To assist the operation of laying the grain towards the cutters, and possibly to steady the revolution of the rakes, two reel arms, or dummies, are also pivoted to the vertical shaft at right angles to the rakes. These revolve with the rakes, but having no teeth pass clear of the platform, leaving the corn to accumulate there. It is evident that if we substitute rakes for dummies, sheaves will be delivered at half the distance, or if we remove the teeth from one rake we shall only make half the number of sheaves, a matter of detail to suit variety of crops. From the side entry of the rakes and the somewhat vertical direction it follows, that with crops leaning from the machine the weight of the heads has a tendency to cause the corn to fall over the top of the rake, in which case, instead of being left on the platform, it is tossed up in the air, and scattered over the surface. This, however, is an exceptional effect, and can be prevented to a great extent by widening the surface of the rake. A piece of No. 5 iron wire may be fastened on so as to give 5 or 6 inches more width, and this answers well.

Messrs. SAMUELSON were also the first to introduce the 'double throw' principle to the knife; that is to say, the knife runs through two fingers instead of one at each revolution of the crank, the object being simply to halve the speed of the shafts, and so decrease wear and tear in the bearings. This firm manufactures a manual delivering machine known as the 'Eclipse,' which is largely used in some districts. The extreme labour in working such machines in heavy, tough crops led Messrs. HORNSBY and Sons to patent an arrangement for assisting the deliverer. This was first exhibited in 1865 at Hereford, and afterwards at the Royal Agricultural Society's trials at Plymouth, where, in a very heavy crop, the advantage was so apparent, that the judges awarded it the first prize in the class. Having written the report of the said trials, we may be allowed to make a quotation, which will give the reader some idea of the nature of this invention. It may best be described as a combination of the grated drop-sheaf platform (i.e. a hinged platform held up by the workman's foot, whilst materials for a sheaf are being collected by him with his rake), which, when dropped, leaves the corn to be carried off at the side by means of revolving steel-forked endless chains. The advantage claimed was the great saving of labour, and the increased attention that could be given by the attendant to collecting the corn. In tangled, heavy crops, whilst his attention in ordinary machines was occupied in removing the corn from the platform, the knife frequently clogged, and drove the tangled beaten-down corn before it. The draught was considerably increased, and the friction of the chains was so great, that after a very short run the patent was abandoned, once again proving how deceptive are short trials; probably if this new machine had been worked for a week its weak points would have been more apparent.

It may be noticed that a swathing machine made by Messrs. HORNSBY, and having the same principle of revolving chains which was awarded the first prize at the same show, has also been abandoned, further experience having convinced this enterprising firm that the future of reaping machinery lay in the direction of Selfable delivery sheafers. Hence their 'Governor,' 'Progress,' and 'Advance' machines—all excellent, and each a decided advance on its predecessor. In the last an arrangement has been attempted by which the driver can alter the direction of the rakes during the progress of the machine, so as to secure an even sheaf when the crop varies suddenly. This adaptibility is also attempted in several of the modern American inventions. As a

rule the object gained is not worth the complication it necessitates, and we would prefer simplicity even though we sacrificed perfection. The principle of the rakes is different in HORNSBY's from SAMUELSON's. The ends of the rake shafts are attached to a pinion fixed at an angle, and driven by a spur wheel at the top of the upright shaft. This, though probably not the most economical as to power, secures a remarkably steady and pleasant action to the rakes; indeed, the manner of laying the corn leaves nothing to be desired.

As an illustration of a modern sweep rake reaper we present our readers with a drawing of WALTER A. WOOD's new reaper, shown at Philadelphia, in which the rake action is controllable by leverage from the driver's foot (*fig.* 2163). The direction of orbit of the rake heads being altered by moving a cam latch connected by wire and cord with the foot leverage. It will be noticed that the rake standard is short and

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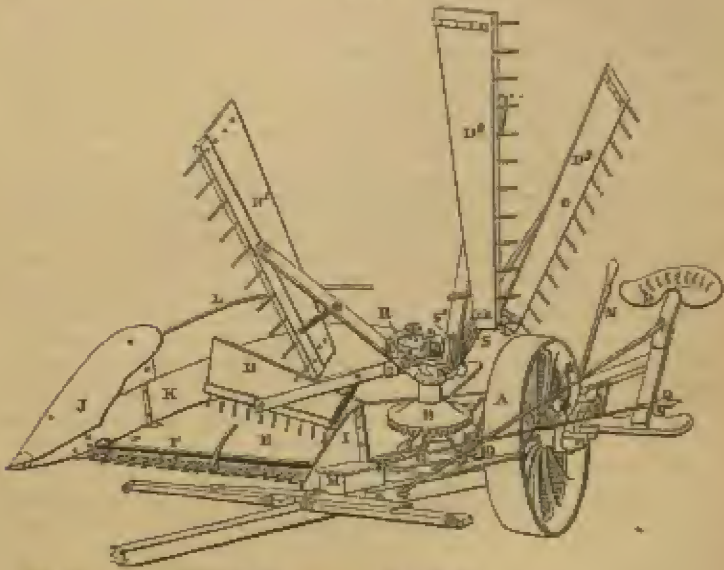


A. Drive wheel, with internal spur gear.
B. Rake standard gear driven by A, by means of cross and rake shafts.
C. Stationary cam for operating rakes.
D, D^1, D^2, D^3. Rakes.
E. Platform.
F. Cutter bar.
G. Pitman, operated by crank shaft, H.
H. Crank shaft.
I. Inside divider.
J. Outside divider.
K. Grain board.
L. Grain rod.
M. Tool box.
N. Tilting lever.
O. Tilting lever arm.
P. Seat.
Q. Foot lever, which operates cam latch lever, R.
R. Cam latch lever, operating foot lever, Q, by means of a cord and wire passing up through the rake standard.
S, S^1. Castings attached to rake arms, to raise R, so that rakes will be raised from platform, E, when there is not grain enough to form a sheaf.

strong. Castings attached to the rake arms, and marked S S', raise the cam latch, and thereby cause the rakes to rise from the platform, so that until the foot lever, Q, is pressed upward, the corn is not raked off. In other words, each of the arms can be made to rake, or the whole kept clear of the table. It will be seen that the attachment of the rake arms is very strong.

Messrs. BURGESS and KEY, having abandoned their swather, after bringing out one of more manageable size and superior construction, and having failed to make a success of MCCORMICK's automaton, owing to the want of balance in the rake arm, and the consequent jerking action, set to work on their own account, and produced the excellent machine with their well-known short connecting rod and knife bar in a line with the axle of the machine. The rake gear being outside the travelling wheel, with the addition of the driving weight, balances the cutting gearing, and the result is a highly effective machine with commendably light draught. There are other makers whose machines are efficient.

The difficulty of dealing successfully with a laid and tangled crop, especially when the corn is laid in the same direction as the traverse of the machine, has led to the introduction of corn lifters, that is, projecting lifters attached to the knife bar frame, and raising the corn in advance of the knife. Such appliances answer to a certain extent, but in such cases it is best to cut across or in a direction meeting the laid corn, and it is often necessary to travel in one direction empty.

For the last two or three years the scarcity of labour has directed attention to the possibility of inventing a machine that will tie up the sheaves as well as cut and lay them out. We believe that Messrs. Hornsby and Sons have quite recently purchased the invention of a Lincolnshire farmer, who has hit upon a method by which this may be effected.

Whilst we in this country are thinking, our American cousins have been acting. Automatic binders have been in existence for some years, and at the Exhibition of 1876, four distinct inventions were exhibited by Walter A. Wood, McCormick and Co., D. M. Osborne and Co., and Mr. McPherson. The three first were successfully worked. The automatic binder was preceded by the harvester, a machine so arranged as to carry two or three binders, to whom the grain is presented in so handy a form, that it is supposed they can make the sheaves. It need hardly be said that the crop must be very light, and the travel of the horses very slow, to allow of three men doing the work that would employ seven or eight hands, who had to pick up the corn and walk. Several of these harvesters were exhibited at Philadelphia, and two were brought to trial. The general construction of these machines is as follows:—First, we have a revolving platform, an endless web either of linen or wood, with spiked projections travelling at right angles to the forward motion. From this platform and over the large wheel is an elevator, which receives the corn from the platform and delivers it on to the binding table, around which the tyers stand on a projecting foot board. The sheaves are either thrown down as made, or placed upon an hinged board, from which they are discharged by leverage from the driver's foot. In this way clusters of sheaves are left ready for stacking. Now the automatic binding apparatus replaces the manual binders; and the mechanism by which this is effected is simple and ingenious, varying in detail in the different inventions, but resulting in every instance in a tightly bound wire tied sheaf. Elaborate drawings would be requisite in order to convey a notion of the mechanism; but we may state that a revolving lever carrying the wire enters the inflowing grain, brings the mass tightly together, causes during the latter portion of its revolution that the ends of the wire should be twisted and cut off when the sheaf is complete. The bundles were in all cases well tied, the tension on the wire being admirably regulated. The size of the sheaf can be regulated by leverage from the driver's foot, that is to say, the action of the binding lever is automatic, except it is interfered with, and the sheaves will vary according to the influx of grain from the elevator, but pressure of the foot arrests the lever arm at any part of its course, and thus the bundles can be made any size that may be desired. We confess to having had a prejudice against the use of wire, believing that being non-elastic, the shrinking of the straw in the drying process would cause the sheaf to become inconveniently loose; also that the wire must be passed through the threshing machine with the straw, and there would be serious risk of portions getting cut up with the chaff and causing injury to cattle, but we have good authority for saying, that in practice no difficulty is experienced. The attendant who supplies the sheaves to the feeder, has a pair of nippers so made that whilst the wire is cut, it is also retained. A box by his side receives the wire, which though not available for use again, can be sold and worked up again. The cost of wire is estimated at 1s. per acre. Whilst automatic harvesters may be well suited to a country where straw is of no value and a high cutting is desirable, we do not think they would answer here, as our crops as a rule are too bulky for such machinery. The tying arrangements are excellent, and something of the same sort may be applied to machines adapted for English crops.

It is a curious fact and worthy of record that whilst the automatic binders were attracting attention at Philadelphia, reaping by steam was attempted in this country. Messrs. Aveling and Porter applied their crane traction engine to drive a large sized Crosskill reaper; on the level, and to a certain extent up a steep decline, the work was well done, and the possibility of the application fully proved. We have an idea that in the future we shall see automatic binders driven by traction engines, and that such machinery may prove of service in the great grain growing districts of the Western States. In this country farms are not sufficiently large to necessitate so powerful a motor. In California at the present time a class of machines (Headers) totally unknown in this country, are largely used. The object is to secure the grain and leave a large portion of the straw behind. The machine consists of a wide platform with a travelling web, and to this platform the material severed by the knife,

which is usually so much raised from the ground as to leave quite half the straw standing, is directed by the action of the reel, and transferred to an elevator at the side, by which it is delivered into an attendant waggon or rulley. The driver of the waggon keeps his vehicle in such position as to receive the heads, which are carried away and stacked in heaps ready for threshing. Some of these machines are as much as 12 to 16 ft. wide, and consequently clear a large area daily. The horses, four abreast are yoked behind, and the driver has a seat at the end of the pole, which helps to balance the machine. Only one such machine was shown at Philadelphia, made by WALTER A. WOOD.

Another peculiarity of American manufacture which has not yet reached this country, is the table and chain rake reapers, the former made by AULTMAN, MILLER, and Co. of Akron, Ohio, the latter by W. A. WOOD. In the table rake the collecting machinery consists of a light reel above and parallel with the knife, and a jointed rake head working on the table itself. The orbit of the rake is determined by a cam, and a jointed shield prevents the straw from choking up the machinery. The arm is driven by a shaft and universal joint, which can be instantly thrown in and out of gear by leverage from the driver's foot. The rake sweeps up the grain, compresses it together at the far corner of the table, and then delivers it in a close neat bundle, which, according to the universal testimony of the binder, was more handy for tying than the bundles from any other machine. It must, however, be borne in mind that in the case of green cut corn exposure is desirable, and the sheaf cannot well be left so open, and if the crop were over ripe the squeeze at the corner of the platform might cause shedding. In Mr. WOOD's machine the jointed rake is driven by endless chains all round a nearly square platform. We should fear too much wear and tear.

It is very instructive to compare recent and early reports of the trials of implements by the Royal Agricultural Society. The latter, as far as they convey any idea of the nature of the machinery, might have been written by schoolboys, whereas some of the later reports, and we would especially indicate that on mowing machinery at Taunton, by Mr. JOHN HEMSLEY, are admirable. Mowing machines originated in America. We hear of them first in 1857 at the Salisbury show, and we have a dim recollection of seeing the trial in some water meadows. On that occasion CLAYTON's American eagle machine did best, cutting low and clean with moderate draught. Motion was communicated from the interior of the travelling wheel periphery by a cam, just in the same way as the knife frame in BELL's reaper was actuated by a cam in a smaller wheel. The cutting arrangement was also very similar in principle to that adopted by the Scotchman, viz. by two rows of blades, the upper ones being in motion, and the lower ones fixed, differing only in the relative position of the active and passive instruments. The judges say 'they are easily replaced, and are less liable to clog or choke than the old plan of cutters and guards. Great progress was visible at the Manchester show in 1869, when this class of machinery was tried, showing a considerable increase of entries over Plymouth in 1865, whilst that meeting was noticeable for genuine improvement over its predecessor. The chief performer at Plymouth was W. A. WOOD, whose well-made machine, comprised partly of wood and iron, was so light in draught and so efficient in work, that it gained the first prize. In this machine the knife bar was jointed to the frame, supported and carried by a strong spring and a slotted brace, running backwards and clasping the main axle of the machine. The knife was capable of being raised above the grass, or set upright for travelling. Another novelty is the small wheel outside the shoe, which can be set so as to regulate the distance of the knife bar from the ground.

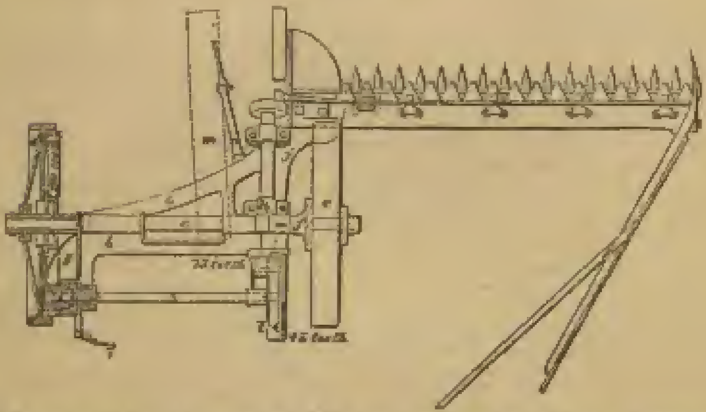
Messrs. HORNSBY, who won the second prize at Plymouth, showed a strong heavy machine which ran steadily and cut extremely well. The points of this machine, were that the finger bar was connected with the main frame by a universal joint, allowing the cutter to be carried up and down over undulations by a front castor wheel. The cutting was perfect, the draught fatal. The greatest novelty in this line was BURGESS and KEY's new mower, which, inasmuch as the principle has been adopted ever since, demands a few words.

In machines previously constructed, the connecting rod, that is, the communication between the crank and the knife bar, was at a considerable angle, in order that the gearing might be clear of the cut grass, and the angular thrust in consequence was attended with some friction. The knife bar was necessarily placed considerably in front or behind the travelling wheel. By using a short connecting rod, the knife bar is capable of being placed in the same line as the axle, or nearly so, and all the gearing, packed up in a small compass, and placed very near the ground, so as to traverse the narrow track cleared by the track board during the previous journey. The connecting rod is nearly in a line with the knife.

All previous trials sink into the shade when compared with that of Taunton in 1865, both as regards the number of machines competing, the quality of work per-

formed, the excellence of construction, and the elaborate modes of testing adopted. Messrs. Hornsby and Sons, who we have seen were awarded a second prize at Plymouth, and were first at Manchester, now carried all before them, taking all the prizes, and being highly commended for a fifth machine. Messrs. Samuelson's reapers were highly commended; and commendations were bestowed on the machines shown

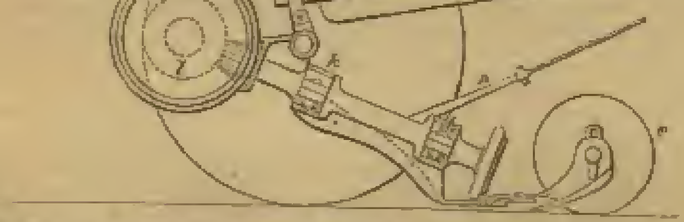
2184



by Burgess and Key, Harrison and McGregor, and Walter A. Wood. In order to effect this extraordinary result, the Grantham firm showed four distinct two-horse mowers, i.e. machines that differed in certain points, and two single-horse mowers, one of which satisfied the requirements of the Society as to draught, and being the only machine that did so, it took the prize.

It is not necessary to waste time over single-horse machines. They are of very little practical use. Possibly cases may occur in which the proportion of mowing grass being small and the horse-power limited, such may be employed, but generally speaking a small man can hire a mower, and get his work done for him, and except the knife be reduced very much, and the machine made too light to stand rough work, the horse labour is severe.

2185



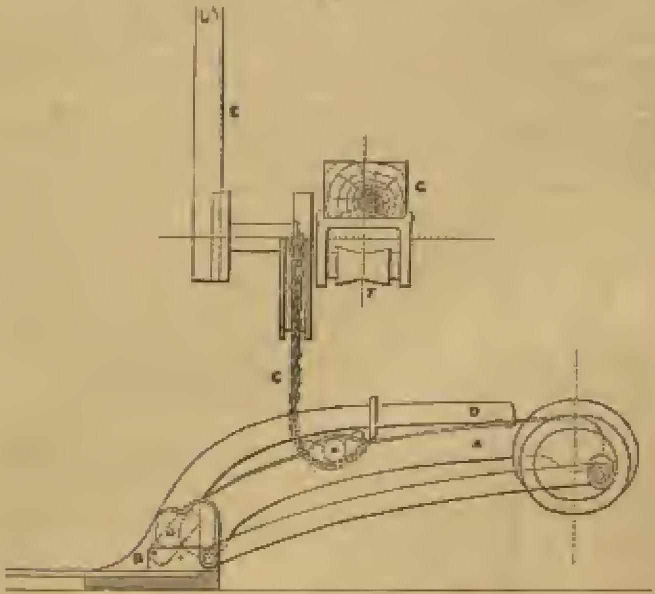
The following details of Hornsby's first prize, two-horse machines distinguished as Paragon O, will give some idea of this excellent machine. *Fig.* 2184 shows the plan, and (*fig.* 2185) the side elevation.

a, the main axle, is of wrought iron, and free to turn in bearings in the frame, *b*, which is of cast iron. Keyed upon it is the ratchet-box, *f*, with which the road wheel, *c*, gears by means of a spring pawl. At the other end is the road-wheel, *d*, biting in

the same way into a ratchet which is formed in the geared ring, which is also keyed to the main axle. This ring carries 100 teeth, working into the pinion, *g*, with 13 teeth. This pinion on the wrought iron spindle, *h*, is thrown in and out of gear by the turn-over lever, *i*, when acted upon by the foot of the driver; at the other end of *h* is a bevelled wheel and pinion, protected from the cut grass by a shield formed on the main frame. This bevelled wheel carries 45 teeth, gearing into 13 teeth upon the end of the spindle carrying the crank. Thus is acquired the second motion and the requisite speed to drive the knife, which is 26·62 of the crank to one revolution of the road wheel, i.e. 2⅝ inches to 1 foot of circumference, the crank having 2⅞ inches' throw. The cutter bar of steel is jointed to the main frame by the caps, *k k*; consequently, however uneven the surface of the land, the crank is always directly in a line with the cutters, and the knife will work equally well at any angle, even when turned up for travelling. This is undoubtedly an important feature in the arrangements. *l* is the main shoe of malleable iron to which the caps are bolted, and the front of which forms the slade, *p*, for carrying the leading wheel. *m*, in dotted line, shows the position of the pole, and *n* is the draught-bar to which the whipple trees are attached by the draught rod; its position on one side of the pole is for the purpose of counteracting side draught when the knife is cutting, and also the weight of the cutter bar upon the land is slightly reduced, so that it has a tendency on meeting obstructions to rise over them. The driver's seat fixes into a socket on the pole bracket; his weight balances the pole. The pole slides to any required position to suit the breadth of the horses' walk.

There are two features in Messrs. SAMUELSON's machines that deserve notice, and are illustrated (*fig.* 2186) and described in the report.

2186

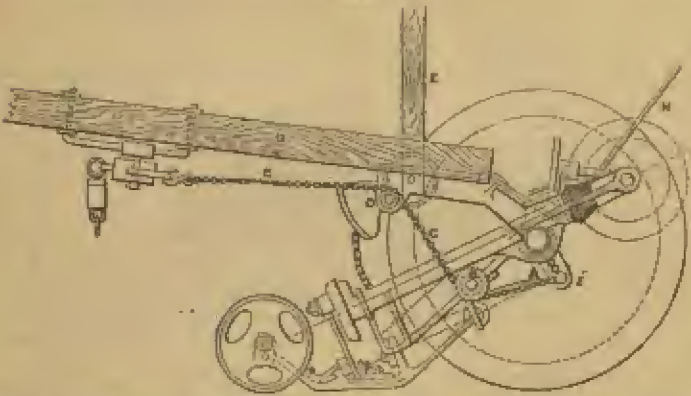


A is a part of the main frame; B B, the shoe and finger bar; C, a chain attached by a loose link to the extension bar, D, running under a half pulley attached to the frame, and connected with a wood lever, E; G is the draught-pole; F, a pulley in connection with the draught chain. When the lever, E, is at rest, the chain is loose and the beam unaffected; when pulled back the chain is tightened, the extension bar, D, is pulled down, the beam rendered rigid from end to end, at the same time lifting the beam and knife over any obstacle. This is a simple and ingenious arrangement.

Our next illustration (*fig.* 2187) shows a side view of SAMUELSON's peculiar arrangement of the draught chain, by which, in case of any undue draught not absolutely necessary in the ordinary working of the machine; the knife bar is raised by the pull of the horses so as to allow it to ride over such obstacles. That this arrangement has

been found practically useful may be gathered from the fact, that it has been applied to all mowers and combined machines made by Messrs. Samuelson and Co. since

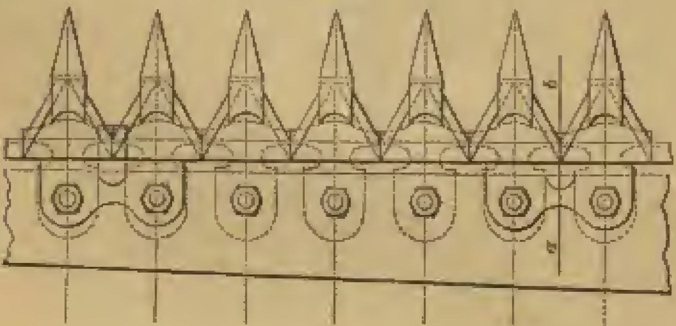
2187



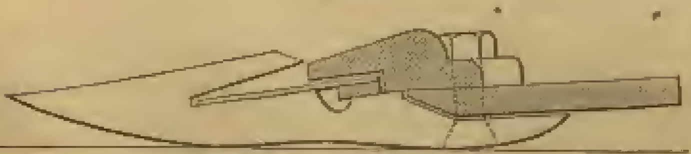
1565. The draught being taken from the extreme end of the pole, the leverage has a tendency to lighten the pressure on the horses' collars. C C is the draught chain, one end of which is attached to the whipple trees, and the other to the tail end of the pole bracket, *i*, furnished with 3 holes for adjustment. It runs under the pulley, B, attached to the main frame, and over the pulley, D, attached to the front portion of the drawing frame. The pulley, D, is adjustable; the pressure of the draught chain it causes the frame to be raised when any extraordinary obstacle intervenes. The attachment of the connecting rod with the knife bar is secured by a spring catch and a pawl—a simple and clever arrangement, facilitating the removal of the knife when required.

Messrs. Samuelson adopt the long connecting rod. It is worthy of notice that

2188



2189

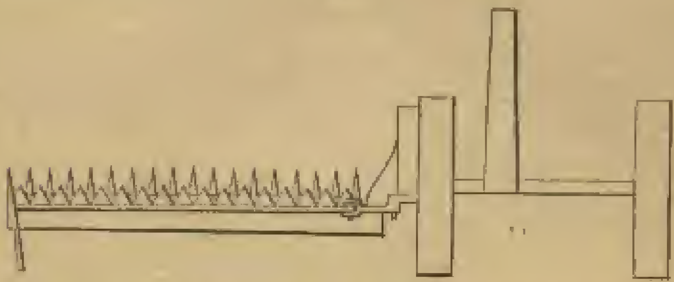


Messrs. Samuelson's machine gave the best results in the dynamometer. Also that Hornsby's machine, with a long connecting rod, was lighter than that which gained the first prize in which the connecting rod was short; whereas Burgess and Key's machine, with the shortest connecting rod, was the heaviest in draught for actual work done

—facts that appear to be in favour of the original arrangement. The preceding drawings (*figs.* 2188 and 2189) show a plan of finger bar and a section of detached finger.

Messrs. BURGESS and KEY, whose machine, though only commended, made excellent work throughout the trials, demands notice for its simplicity and good construction. The position of the knife in reference to the main axle will be understood from the following plan (*fig.* 2190):—

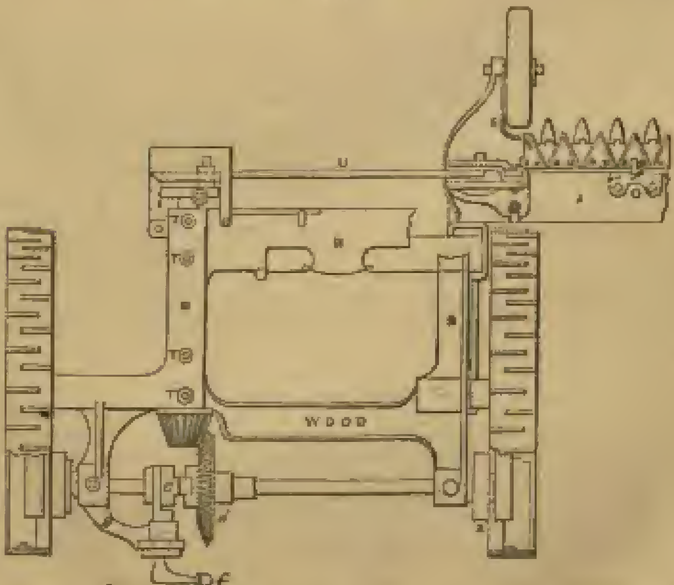
2190



A clever arrangement in this machine allows of the introduction of different sized pinions, by which three different speeds for the knife are obtained. This is done by the driving wheels working on an eccentric bush, which, on being turned round on its own pivot, moves the driving wheel off from the wheel it gears into, and so allows of the alteration of pinion. The speed can be varied to the extent of 25 per cent. As the knife cannot be removed conveniently by sliding out in the usual way, the ordinary guide bar is exchanged for a movable one, and when this is taken off the knife is free.

Although not an English invention, we cannot avoid a short notice of the mowing machine of WALTER A. WOOD, which is used to a considerable extent here: and so great has been the trade in these machines that it is said that, at the works in

2191



America, a machine can be turned out of hand every five minutes. This machine has one great advantage: that it is made of best Pennsylvania cast iron, which is twice

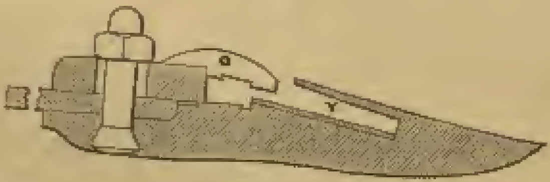
as tough as ordinary English cast iron. This is a great advantage in favour of the American invention. Many of the machines—Wood's being an exception—are often somewhat roughly constructed, but the material is always good. The following short description of the principal points in the Wood mower will give an idea of construction:—

And first, as to material. The driving wheels, main frame, gearing wheels, shoe, and small wheel in the shoe, are made of Pennsylvania cast iron. The cross shaft and crank shaft, axle, cutter bar and knife bar, are of cold rolled iron, which is considered stiffer and harder than ordinary bar iron. The guard fingers and dividing shoe are of malleable iron, steel faced. The total weight of the machine exhibited at Taunton, and which made such good cutting as to be commended, was 5 cwt. 2 qrs. 9 lb., one or two English machines only being lighter. Mr. Wood has devoted his sole attention to mowers and reapers ever since 1852. It is not, therefore, surprising to find much merit in his arrangements. The preceding plan (*fig.* 2191), with explanations which we take from Mr. HELMERE's excellent report of the Taunton trials, will show the nature of the mechanism.

The spur pinions, X X, are fixed on the cross shaft; each have twelve teeth, are both provided with ratchet and pawls, so that if either travelling wheels advance the cross shaft rotates. On the shaft is placed the bevel wheel, *d*, with 45 teeth, working into the bevel pinion, *b*, at one end of the crank shaft, which is 22 inches long, having strong bearers and oilers, shown at T T T T. The crank, I, drives the connecting rod, U, which makes 54 vibrations to 1 revolution of the driving wheel, or 7·4 to 1 foot. The inclination of the connecting rod is 6½ in. *f* is the lever worked by the attendant's foot, which throws the bevel wheel, *d*, in or out of gear by the clutch, *e*, supported in its place by the arm, *g* (*fig.* 2192). It will be seen that the outer surface of the wheel tires are provided with transverse ribs, which are of use in causing a bite on the ground. The form of the fingers, knife holder, and thickness of steel facing will be at once seen by reference to the following section, in which O is the holder, Y the steel facing.

2192

2193



As an illustration of divergence from the recognised type, we may notice the Eureka direct draught mower (Towanda, P.A.), which was shown at Philadelphia, and was very favourably noticed by the judges. The knife works in front of and between the driving or travelling wheels, which are of large size. The pole is placed in the centre of the machine, equidistant between the wheels; and the horses, 2 in number, are so attached by means of a long neck yoke that whilst the near-side horse walks close to the standing grass on the land cleared by the track board, the off horse walks on the grass, but outside of the line of cut; consequently, his treadings are met by the machine on the return journey, and cut clean. The great advantage of this arrangement is the economy of power, owing to the direct and uniform strain, the ability to deal with a crop in any direction, so that if laid in one direction the whole can be cut across, and the fact that, having two track clearers, the grass is laid up in a small windrow exposed to sun and wind, and in a position to hay without any further operations, a point of great importance as regards clover. The results by the dynamometer were highly satisfactory, being considerably the lightest draught of the 20 machines tested, and two horses worked a 6-ft. machine with comparative ease. We believe that a still larger size is made, but we think the medium preferable. The knife bar is flexible. We think this machine worth trial in this country.

The haymaker mower (OTIS BROTHERS, New York) attracted much attention at the Exhibition, on account of the novel means by which motion is conveyed to the knife. Instead of the usual arrangements of shafts and gearings, we find only a single pair of bevel wheels. The axle which revolves carries a small bevel wheel with 46 teeth,

a similar wheel in all respects, only having 2 more teeth gears into this; but owing to its being hung on a gimble joint, like a ship's compass, it does not revolve, but makes a succession of rapid serpentine vibrations, around the face of the other wheel. This motion at one end of a lever suffices to produce a rapid motion to the knife at the other, and thus we get all that is wanted with a minimum of friction. The motion is exceedingly smooth and pretty, and as 5 or 6 teeth are always engaged at once, the wear is more evenly distributed than in ordinary gearing. The draught tested by the dynamometer was reasonable, and the horses appeared to find easy work. Owing to the absence of gear, it is quite noiseless in running. Such a machine ought to command a large sale, on account of its simplicity.

Enough has been illustrated to prove that mowing machinery has kept pace with other inventions during the past 25 years. The price is so moderate, from 20*l.* to 21*l.*, that they are within reach of all who have as much as 20 acres of grass or clover to cut, and the wants of small farmers are further met by the introduction of combined machines, which are equally effective either as mowers or reapers. Of course such a double purpose renders the machinery more complicated: thus, for example, in order to cut grass the throw of the knife must be faster than when required to cut corn; hence we must have two speeds. This is effected in various ways—probably the simplest is that first adopted by Mr. Adam Bamlett of Thirsk, and consists in having bolted to the travelling wheel 2 toothed wheels, with internal and external gearing, and a sliding pinion on the cross shaft. The internal wheel, having the larger circumference, drives for mowing. A very similar plan is adopted by Messrs. Picksley, Sims and Co., only the gearing wheels are placed one in each of the travelling wheels. There is, of course, some little time required to convert a mowing machine into a reaper; and although in a few cases we find self-delivering reapers combined with mowers, it is generally only applied to the manual machines. Those who have sufficiently large farms will find it better to use separate machines. We have said that with 20 acres to cut it will pay to have a machine. The following calculation justifies our statement:—

	Per acre. s.	d.
Interest and wear and tear at 10 per cent. = 2*l.*	2	0
Horse labour and attendant	1	3
Oil, &c.	0	3
	3	6

Mowing a heavy crop, especially of grass, would cost at least 6*s.*, and often much more; and however skilful the workman, the grass cannot be cut so close or evenly. There is a feeling in some districts that the action of the knife in cutting is prejudicial to the after grass—that the cut is not clean like the scythe, but somewhat jagged. We believe this is quite erroneous, and arises from the fact that the grass being shaved so much nearer the ground, there is less cover from the drying effects of the sun; consequently growth is slower, and naturally there is less show of grass for some time. Were it true, the repeated use of the mowing machine for so many years should have caused a marked deficiency in the crop and growth, which is certainly not the case.

In reference to the harvesting of hay, we must notice a recent American invention, Faust's hayloader (Messrs. Stratton and Cullum), which appears a most valuable labour saving machine. Hooked on behind any ordinary wagon or cart, it comprises a revolving spindle on high wheels with forked projections, which catch up the hay out of windrow, throw it on to an elevator protected by a windguard, which delivers it into the wagon. We saw this thoroughly tested, and came to the conclusion that it saved the work of four men. Hay forks and conveyers facilitate the storing of hay in mows and barns.

With the introduction and practical perfecting of steam cultivating machinery, and with the degree of excellence arrived at in horse ploughs, it was thought that invention could not go much further in this direction. Yet it has been reserved for our day to see an important addition to our appliances for light land culture in the form of the double plough. To Mr. Pirie, a Scotchman, belongs the credit of resuscitating an old friend, and making it really available. The double plough was in its wooden and somewhat primitive form known to and often used by our ancestors. The farmers on the Cotswolds yoked their 4 or 6 oxen to such an implement, and worked the barley land after turnips with much advantage. It had wooden mould boards and a double beam, the one plough being set in advance of the other. The nearest resemblance to the original was a plough still made by Mr. Cooke of Lincoln, with wooden beams. The original Pirie plough has, in the hands of Messrs. John Fowler and Co., been much improved upon, Messrs. Hornsby and Sons adopting a very similar pattern as

to frame—which, by the way, closely resembles the framing of the balance steam plough, only very much lighter, consisting of T-shaped iron. Messrs. HOWARD of Bedford, and Messrs. RANSOMES and SIMS of Ipswich, exhibited double furrow ploughs with parallel beams—a form which both firms retain—at the Leicester meeting in 1868. In most of these inventions exists some mechanical arrangement for facilitating the carrying round of the frame, together with the raising of the shares clear of the work at the land's end. The complication varies, and the necessity for anything of the kind depends upon the weight of the frame. Frequently this is effected by altering the position of the land side wheel, and of a corresponding wheel or skid which travels behind the first plough, both being suspended from a cross bar and actuated by a leverage, the handle of which is within reach of the ploughman. Another feature in the double plough consists in the substitution of a friction wheel set at an angle, in place of the sole and land side of an ordinary plough, securing a rolling instead of a sliding friction.

The advantages of the double plough for light and medium soils are the saving of at least 25 per cent. of horse labour; thus the dynamometer proves that in good machines 3 horses yoked abreast can execute a given work as well as 4 horses in two ordinary ploughs; in other words, the draught of 2 furrows attached to a double plough—is less than 25 per cent. than the combined draught of 2 separate ploughs doing similar work. One ploughman can do as much ploughing as 2 men with ordinary ploughs. This is a great advantage, and it is not surprising that a great trade has sprung up for double ploughs. The only trial that has been conducted under the auspices of the Royal Agricultural Society, and therefore we venture to say the only exhaustive one in this country at least, was at Hull in 1873. Unfortunately, the Vienna Exhibition was in progress at the time, and this was urged as a reason why certain leading makers should be allowed to exhibit their goods without competing. The Society unfortunately, as we think, allowed this irregularity; notwithstanding the defalcation of so many leading men, the entries were numerous, and many of the machines possessed considerable merit. Younger firms got an opening, and Messrs. G. W. MURRAY and Co. and J. D. SNOWDEN of Doncaster were awarded the prizes for very good implements.

When it is remembered that 25 years since more corn was threshed by the flail than by any other system, that the usual kind of machinery consisted of a drum driven by horse gear, which simply threshed out the corn fed slowly into it, the student who minutely studies one of our best combined machines will be fain to admit that remarkable progress has been made. At the time of which we speak, Scotland was decidedly in advance of England; indeed, to Mr. A. MEIKLE, of Houston Mill, near Haddington, is due the honour of having been the first to invent the threshing machine. This was in 1798. It comprised a rapidly revolving cylinder, with raised edges or beaters, parallel to its axis, standing out from its surface. This cylinder was covered by a concave surface, placed 2 or 3 inches from the surface described by these revolving beaters. Feed rollers held the corn whilst being beaten by the drum. This was a great advance upon an earlier scheme of revolving flails. In Mr. MEIKLE's invention the separation, or rather the detachment, of the grain from the straw was all that was attempted; the straw, chaff, and corn fell together, and was separated by manual labour. The next great step was the introduction of straw shakers, which in the Scotch machines consisted of 2 wooden drums, the one next to the threshing drum being the largest. These were furnished with a number of forks or spines, which caught the straw and carried it round, the grain passing through a concave screen underneath the shakers, and falling with the chaff and pugs—i.e. unthreshed heads—into the hopper of a winnowing machine. After passing through this, it is elevated into a second winnower, whilst the pugs are delivered by other elevators to the drum to be again passed through the machine. Such was and in many cases is the Scotch threshing machine, which is fixed in the barn, and worked nearly entirely by toothed gearing, and driven either by a fixed engine or by horse-power.

The great difference between such a machine and those used in this country now consists in the action of the drum. It will be understood that the action of the Scotch drum depends upon the grain being slowly presented, and receiving a succession of blows at right angles by the protruding beaters—a system which eventually separates the grain, but does so at a great expenditure of power, and frequently knocks off whole ears, as is proved by the necessity for rethreshing the pulls or pugs, as they are called. In the Scotch drum the revolutions of the drum are upwards, and the corn, when liberated by the feed rollers, is carried between the upper concave. In the English drum the revolution is in the opposite direction, the beaters are more numerous, and only raised about half an inch from the surface of the drum, and the corn is fed in nearly parallel to the axis of the drum. The grain is scutched or stripped, and in passing between the beaters and the lower concave is entirely

separated and rubbed; so that not only is the grain detached from the straw, but the chaff is also almost entirely removed. This is the great difference between the Scotch and English machines. We adopt the up-and-down motion of crank-driven shakers, which convey the straw by a series of jerks from the drum to the point at which it is delivered, any loose grain carried along with the straw being thus separated and passing by an inclined plane back to the blower. The necessity for economy of space in our portable machines which are so commonly used has been studied with excellent effect, and the improved double dressing and finishing machine of to-day is a triumph of designing skill.

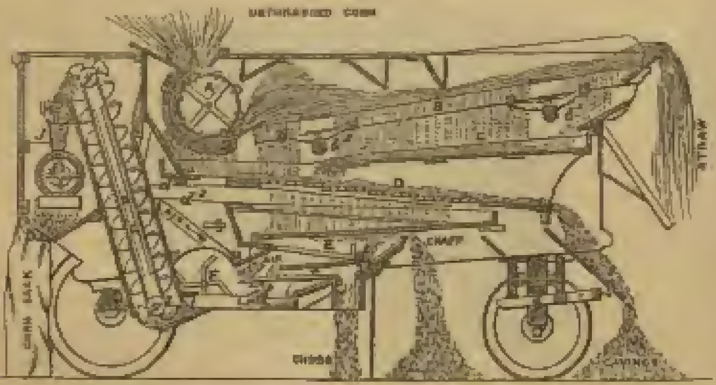
We select for illustration the portable combined finishing machine of Messrs. MARSHALL and SON, of Gainsborough, which was awarded the first prize of the Royal Agricultural Society at their Cardiff trials, and in doing so avail ourselves of the illustrations and descriptions by Mr. C. J. ROBERTS, the Society's reporter. In taking this particular machine, we do so simply from the fact of its having gained the first prize. The machines made by CLAYTON, SHUTTLEWORTH, and Co., RANSOMES and SIMS, RUSTON PROCTOR, &c., and many others, are excellent in construction and efficiency. The following view (*fig.* 2194), showing the back part and right side of the machine, will convey a good idea of the snugness and economy of arrangement of the various parts. All motion is communicated by belt to the axle of the drum, and

2194

it will be seen that the position of the different parts driven from the drum axle are arranged with a view to counterbalance the strain or pull upon the bearings of the drum spindle. Thus the cross strap, passing forwards, drives the crank shaft, shown at b^1, in the longitudinal section (*fig.* 2195); another strap in the opposite direction drives the smutter, H; whilst the third leads downwards to the pulley of the crank shaft, which works the caving riddles and the shog board, C. This last strap is particularly well placed, as it tends to counterbalance the pressure, upwards and forwards, of the corn passing between the drum and the under concave. On the opposite, or left hand, side of the machine only one belt leads from the drum spindle; this drives the shaft below the frame, on which two sets of fans, F, are fixed. The other necessary motions are derived from secondary sources. Whether the arrangement and balance of these forces are peculiarly favourable, or owing to some other cause, the different parts of this machine work together with a minimum of vibration; we have not found any machine more steady. The drum, a skeleton cylinder of wrought iron, consists of three rings keyed upon the central shaft or spindle, bearing 8 wrought-iron bars; upon which the beater plates of mild steel are fastened, length 53", diameter 22". The concave, a wrought-iron grating embracing more than half the circumference of the drum, is formed of bent iron wires and longitudinal iron bars, 2 inches apart, which are seen in the above section. The wires are ¼ in. in diameter, the interstices $\frac{5}{16}$ths of an inch. The bulk of the grain and chaff, rubbed between the concave and the drum, falls through the former on to the riddle, D. The rest passes with the straw on to the shakers, B. The five shakers each ride upon the crank shafts, b^1 and b^2, which make 160 revolutions per minute; each shaker has a separate and independent motion, by which the straw is forwarded by a series of jerks, and the loose grain is thoroughly separated and falls through the open spaces of the shaker on to the inclined and oscillating board, C, and so finds its way to the end of the caving screen.

The oscillating board and the riddles are hung by wooden spring suspenders, seen in the view, and are swung to and fro by connecting rods (d and d^1)—seen on section—from a crank shaft, which is placed above the hind wheels of the machine, and makes 200 revolutions per minute. The caving riddle, D, is slightly inclined and broken by four steps pierced with cylindrical holes, varying in size according to the kind of corn threshed. The cavings are delivered, and pass over the riddle; the chaff and grain fall through the holes upon a fine wire network, which removes the small seeds and dust. The chaff and corn are next conducted to the sieve, E, falls through this and e, is conducted by the shoot e^1 to the receptacle at the bottom of the elevator, G. The fan, F, revolving 680 times per minute, directs two blasts of air against the under sides of sieves, E and e, and effectually removes everything that is of a light nature, and the chaff in particular. The chaff, instead of escaping on the ground, can be hoisted sack-height, and delivered into sacks: the chaff apparatus, however, costing 5*l.* extra. The chobs are separated from the corn by the first blast, and, striking against the sliding board, are delivered into a basket below. With the exception of beans and peas, which are let out of a trap-door, all other corn is carried up to the smutter by means of the elevators, and passed through a tube containing a shaft, furnished with beaters. This revolving rapidly, has an excellent effect upon the appearance of the sample. The sides of the cylinder are of fine wire, through

2195



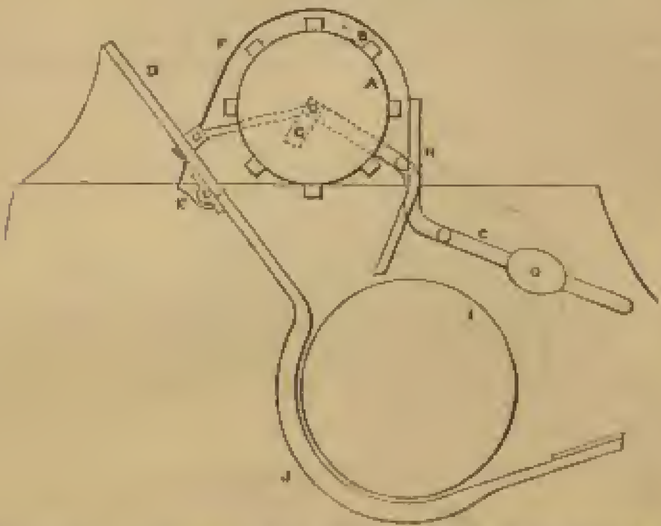
which dust can pass, whilst the corn, owing to the screw-like action of the spindle, is propelled forward. The amount of rubbing is regulated by a slide at the further end of the smutter case. As the corn falls from the smutter it is subjected to a second blast from the fans of the windcase, I, which carries chaff, awns, &c., back under the drum concave and on to the caving-riddle. The corn passes down the spout, j, into the rotary RAINFORTH's screen, J, which makes 40 revolutions per minute, and delivers into the spout, as best corn, seconds, and thirds. If desirable, the machine can be used as a single dresser, in which case the corn, when delivered from the spouts, is allowed to pass into sacks through a trap-door to the sack spouts, instead of passing through the smutter case and second dressing machine. The frame is of oak well braced.

This is a very complete machine, making excellent work; inasmuch, however, as all the speeds are derived from and depend for regularity upon the drum, it follows that any cause which disturbs this regularity must affect the whole of the processes; and supposing, through the carelessness of the feeder, a sheaf is put in either whole or imperfectly divided, a visible check occurs, accompanied by a throb throughout the machine, which affects every motion, less wind is brought to bear upon the grain, and the sample is not properly cleaned. Hence it follows, in the case of barley more especially, that in order to have a first-rate sample it is always best to shoot up the head corn and put it through a blower. Granted perfectly uniform feeding, and that the article supplied was of similar quality throughout, this and other first-rate combined machines prepare a sample fit for market, and we are justified in saying that such a machine or compound with the horn drum of a quarter of a century shows immense progress.

This difficulty as to the feeding, and the fact that several accidents have occurred, owing to the work-people getting into the drum, led the Royal Agricultural Society

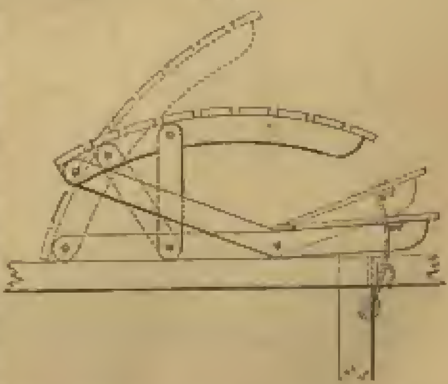
to offer special prizes, both for drum guards and combined guards and feeders. With regard to the former, a large number of inventions were tested at Taunton in 1875, out of which the judges selected two as most efficient and practical. That which gained the first prize was shown by Mr. J. P. Fison of Cambridge, which, at an additional cost of 7*l.* 10*s.* secures perfect safety to the work-people. The second prize was awarded to a much simpler design of Messrs. Tasker and Sons of Andover. The following illustration (*fig.* 2196) will assist the reader to understand the nature of

2196



Fison's guard. A is a wooden drum, cased with sheet iron and carrying eight bevelled wood projections, 1 x 1½ in. It is driven at 100 revolutions per minute by a strap from the shaker spindle below. It is supported at either end by two balance levers, C, connected with the swinging feed board, D, hung on pivots, E. The spindle of the cylinder is not fixed, but can play up and down in the slotted iron brackets, G, 3¼ in. When compressed, either by a person falling on to it or by the extreme weight of corn, the drum falls to such an extent that the strap becomes slack, the cylinder ceases to revolve, and the mouth of the drum is effectually closed. The same thing occurs if the man falls on the feed board at D, the weight pulls down the board, and consequently the cylinder closes the opening. When the weight is removed, the cylinder adjusts itself by means of the lever, C, and the belt is again brought into action. The drum opening during work is only 3½ in., but the projections on the cylinder materially assist to draw in the feed. The drum and concave are shown at I and J.

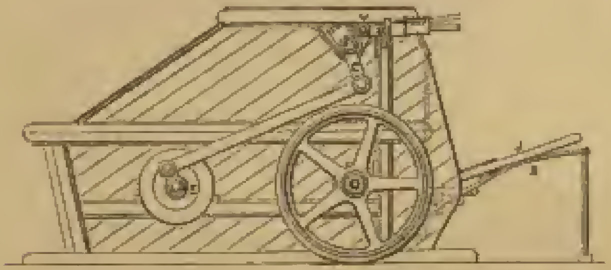
2197



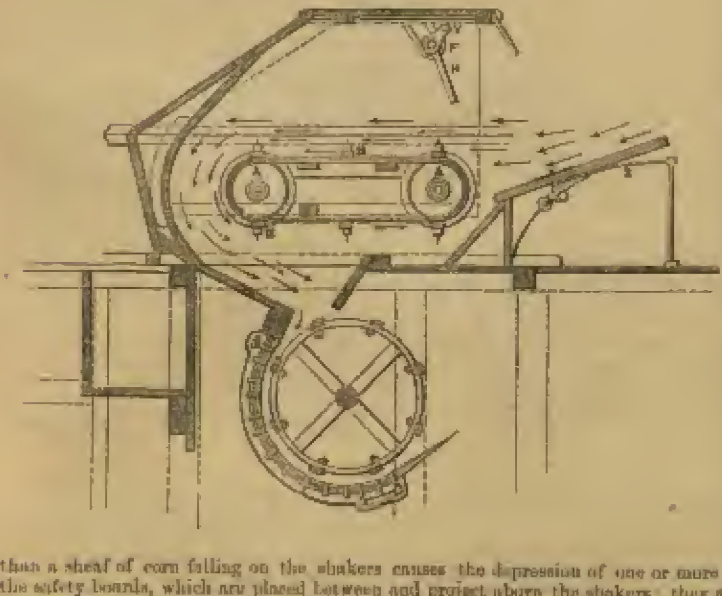
Messrs. Tasker's arrangement, which gained the second prize, comprises simply a lever cap or bonnet. The dotted lines (*fig.* 2197) show the position of the bonnet during work. The lines in black the position assumed when a sufficient weight is brought to bear on the feed board or the back of the hood. The illustration sufficiently explains the mechanism, which is extremely simple and effective.

More difficulty was found in deciding upon the combined guards and feeders, inasmuch as one element of merit required, was that such appliances should save labour, and this is quite right since they add materially both to the cost of the machine and the power required to drive it. In no instance was an appliance found as efficient as an expert man feeder. Messrs. Clayton and Shuttleworth's combined guard and feeder (Wilder's Patent) was considered much superior to any others. As this is a somewhat complicated arrangement, we must content ourselves with a short description. The corn is thrown on to vibrating boards, similar in action to straw shakers, worked by a crank driven by straps from below, and is thus brought by a series of jerks a distance of 5 or 6 ft. to the mouth of the drum, and would be pressed in but for the regulating and dividing action of seven vibrating teeth, which open out the sheaves and allow only a certain regulated quantity to pass. Any weight greater

2198



2199



than a sheaf of corn falling on the shakers causes the depression of one or more of the safety boards, which are placed between and project above the shakers; they are in connection with levers which throw the driving strap on to a lever pulley. The shakers instantly stop, and all danger ceases. The attendant can equally throw the feeder out of gear, if required, by means of a lever handle at the back of the bonnet. Elaborate trials were carried out which proved that more corn could be passed through the machine by a good feeder than with the apparatus, and that little more than half a horse power was consumed. The cost 20*l*. We believe a considerable demand exists for the feeder in foreign countries.

especially Russia, where previous to their introduction, accidents were of frequent occurrence.

The second prize was awarded to Messrs. MARSHALL and SONS, whose apparatus will be best understood by reference to the preceding illustrations (*figs.* 2198, 2199), which show the side elevation and longitudinal section. The principal feature consists of two endless 3-in. leather bands working over turned pulleys, A A, at each side of the feed opening, to which are attached wooden cross-bars, B B, carrying at intervals short iron tines, 2½ in. long, in such positions as to alternate with each other. At a convenient height above the platform is a series of 10 prongs, to which an oscillating motion is given by means of the shaft, F F, the crank, G, and the pulley, H. The position of the shaft can be adjusted to suit different work. Motion is got from the shaker shaft by a belt, fast and loose pulleys being employed. A lever is used for throwing the apparatus in and out of motion. The receiving board is hinged and carried on a spring, E, so that if any pressure is thrown upon it, as would be the case if the attendant fell, the board yields, and the strap is forced up on the loose pulley, and the feeder instantly stops. This appliance actually assists the work, more material passes through the machine with than without it. The price was the same as CLAYTON'S. The power [illegible]ths as against [illegible]ths of a horse power.

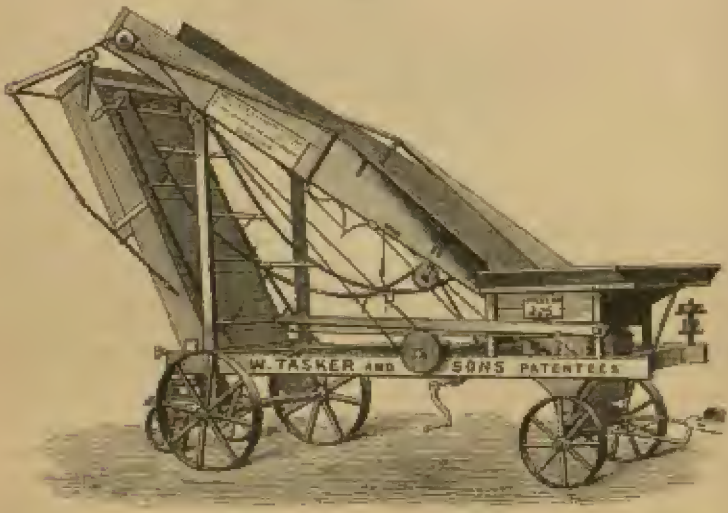
Such machines as MARSHALL'S, CLAYTON'S and others, are capable of threshing from 50 to 60 quarters of barley a day, less wheat, as the straw is generally longer, and even a larger quantity of oats. In cases where the straw elevator is used, and things are well arranged, the hands required to keep everything going, do not exceed eight or nine, and two of these may be women. The elevators are quite modern inventions; the original was, we believe, made by a Mr. HAYES of Elton, Northamptonshire. At the present time each of the leading makers supply a form of their own. At Hull in 1873 the Royal Agricultural Society offered special prizes, and had a very interesting trial; an adjournment from the previous year at Cardiff, where owing to the pressure of other work, proper attention to this section was impossible. At Cardiff the prizes were awarded to Messrs. MARSHALL and Co., CLAYTON and SHUTTLEWORTH, and W. TASKER and SONS, in the order named. At Hull the two former did not compete, and Messrs. TASKER and SONS in a class of nine competitors won the prize.

2200

It will be seen by the subjoined illustration (*fig.* 2200) that each machine is provided with a horse gear, so as to be equally available for stacking hay, for which purpose they are frequently employed, to the manifest saving of very laborious work. Our illustrations show Messrs. TASKER'S machine ready for work and folded up for travelling, in which condition it is readily moved by one horse. A strong wooden

framework supports the elevator, which is carried on four iron wheels. The hopper which receives the straw from the shaker is round. The trough, which it will be seen by the second illustration is jointed at about $\frac{2}{3}$rds of its length, is raised by wire ropes wound upon grooved pulleys, and fastened to the heads of the two movable shafts, which terminate in friction rollers; it will be seen that the bottom of these shafts revolves upon the axle of the fore wheels. It is very easy to understand the mode of raising and altering the angle of the elevator. The friction rollers at the top of the shafts run beneath metal rails on the under side of the trough. At

2201



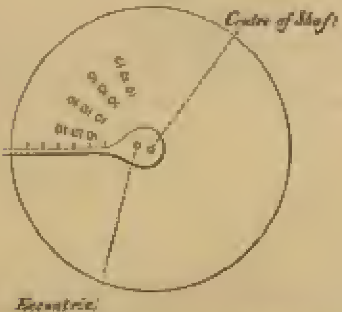
their lower extremities these rails are made to project from the trough. As soon as the shafts are drawn back far enough to reach the curved parts of the rails, the trough itself rises at a quicker rate, and the friction rollers at the end of the shafts begin to act as pulleys to the ladder chains, and this secures their proper degree of tautness. This arrangement is ingenious and effective.

Our necessarily short notice of some of the more prominent inventions and improvements that have characterised the past 25 years would be incomplete if we omitted reference to the machinery employed in the preparation of food for cattle. For a long period after the general introduction of roots as a field crop, hand slicers were the only means of their reduction for cattle, and next slicing machines on the same plan as the Gardner's sheep cutter, were used. Cattle were supplied with an unlimited quantity of sliced roots and long hay. Such a method of feeding was costly and unscientific. The large volumes of water introduced by the roots, consumed much of the heat of the body; great waste ensued. By means of the pulping machine and the chaff cutter, and the judicious mixture of artificial food, a much larger quantity of meat can be made from a given amount of food, and growing animals maintained in an improving condition at half the cost. These are very important facts, affecting the consumer as well as the producer. Pulping machines are constructed on two distinct principles. In one the knives are fixed in a revolving barrel, and the root is held by the hopper or rolled round and round until it is torn in pieces, much of the juice being thus extracted. In the other and more perfect kind, the operation is effected by an upright disc revolving in a hopper, so shaped as to hold the roots up to the surface of the disc.

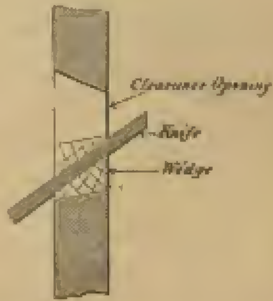
In Messrs. Hornsby's machine, which took the prize at the Oxford meeting in 1870, the cutters on the disc radiate from the centre, each knife is distinct, being held in place by a key. The chief peculiarity consists in an eccentric cleaning bar furnished with a number of small projections which traverse the spaces between the knives, keeping them clean and also insuring the last piece being cut, as it cannot escape, except through the round openings in the disc above the knives, which are only $\frac{3}{8}$ths of an in. in diameter. The eccentric is $\frac{5}{16}$ths of an in., and the traverse

of the bar, [illegible] of an in.; the knife points being arranged in circles at [illegible] distances, struck from the eccentric and not from the centre of spindles, insures their passing between the projections of the bar. This will be understood by the following diagram (*fig.* 2202), which shows a plan of the disc. Each knife has [illegible] of an in. wearing surface. There are 12 rows of knives, 13 in each row. Each knife is perfectly independent of the others, and can be removed and renewed at a cost of 3d. The following section of the disc (*fig.* 2203), shows how the knife is secured.

2202

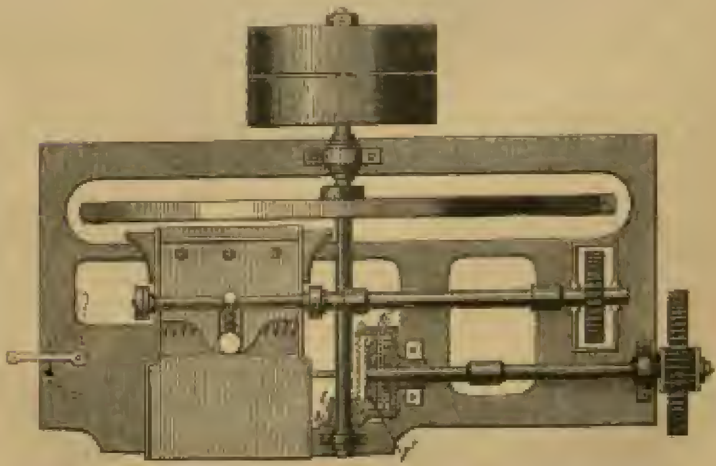


2203



In the matter of chaff cutters Messrs. Richmond and Chandler have taken a decided lead, their machines working with considerably less power than any other; this is due principally to the economical arrangement of the gearing, which we shall endeavour to describe. The upper jaw of the mouthpiece expands according to the nature of the substances to be acted on. It is hinged to the axle of the upper toothed roller, and kept down by a hand screw. The process by which motion is communicated from the fly wheel to the feed rollers is very simple and direct. On the fly-wheel shaft are fixed 2 bevel pinions, gearing into 2 wheels of different diameters, the smaller of which is fixed to the line shaft, whilst the other is loose:

2204



and they are connected when required by clutch gear. The pinion k (*fig.* 2204) gears into the loose wheel k^1, whilst the pinion l gears into l^1, which is keyed on the shaft. When the clutch boxes are in gear and the larger wheel is being driven, the line shaft imparts a slow motion to the toothed rollers by the usual change wheels and pinions shown at m^1; and when the clutch boxes are out of gear and the smaller wheel on the line shaft is being driven, the rollers revolve at a greater speed. The necessary

alteration of the line shaft is effected by a starting rod through an eccentric handle. It will be seen that the gearing on the line shaft is placed as near the fly wheel as possible, which probably accounts for the economy of power. On each side of the mouth are strong spiral screws replacing the weight lever, with this advantage, that the pressure increases as the feed becomes thicker. In place of the ordinary fixed bed of the feeding box, a travelling web is introduced. This is carried on a pulley fixed just below the fan rollers, and driven a trifle faster than the latter, in order that the straw may be ready for the roller. This, though not a self-feeder, is a great help to the assistant, who, not having to pull the stuff forward, can concentrate his whole attention on the feed.—J. C.

AIR-HOT ENGINES. (Vol. I. p. 36.) See Caloric Engines.

ALABASTER, CALCAREOUS. (Vol. I. p. 40.) (*Albâtre*, Fr.; *Alabaster*, Ger.) This material from Mexico, known in commerce as the *Onyx of Tecali*, varies in colour from milk white, yellowish white to a pale green, some samples displaying brown veins shading into red. It takes a fine polish, and is much used for ornamental purposes. Its composition is—

Carbonic acid	43·52
Lime	50·10
Magnesia	1·40
Oxide of iron	4·10
Oxide of manganese	0·22
Water	0·60
Silica	traces
	99·94

M. A. Damour, *Comptes Rendus*, May 8, 1870

ALBERTITE. (Vol. I. p. 41.) *A variety of coal.* This remarkable mineral, occurring in connection with the calcareo-bituminous shales, was first discovered about the year 1850, and has been by some regarded as a true coal, by others as a variety of jet, and by others again as more nearly related to asphaltum. It resembles the latter closely in appearance, being very black, brittle, and lustrous, with a broad conchoidal fracture, and, like asphaltum, is destitute of structure, but differs in fusibility and in its relation to various solvents. It differs from true coal in being of one quality throughout, in containing no traces of vegetable tissues, and in its occurrence, as a vein, and not as a bed. The vein occupies an irregular and nearly vertical fissure, and varies from 1 inch to 17 feet in thickness. It has been mined to a depth of 1,162 feet. The accompanying shales are in some portions abundantly filled with the remains of fossil fishes (*Palæoniscus*), and it is not improbable that it was from these, in part at least, that the mineral was derived, existing perhaps at first in a fluid or semi-fluid condition (in which state it has in some instances become the cementing fluid of conglomerates), and subsequently being altered into its present form. Vegetable remains are almost entirely wanting in the shales.

Since the first discovery of the Albert mines the amount of mineral exported, chiefly to the United States, has been very large. The following are the shipments for the twelve years from 1863 to 1874 inclusive:—

	Tons
1863	18,600
1864	19,300
1865	20,500
1866	20,600
1867	17,000
1868	12,400
1869	17,000
1870	6,000
1871	5,500
1872	5,000
1873	6,000
1874	7,000
Total in 12 years	154,800 tons.

The royalty paid to the Government up to January 1, 1866, was $8,080·29.

The mineral has been used in the United States partly for the manufacture of oil, and partly for admixture with ordinary bituminous coals in the preparation of illuminating gas. For either of these purposes it is admirably adapted, yielding 100 gallons of crude oil or 14,500 cubic feet of gas of superior illuminating power per ton. When employed with coal it leaves as a residuum a valuable coke. It is hoped

that explorations now in progress may result in the discovery of other extensive deposits. The price has varied at different times from $15·00 to $29·00 (gold) per ton.—*Notes by the Geological Survey of Canada.* Philadelphia Exhibition, 1876.

ALBEFACTIO. A condition produced in plants by the absence of light., blanching, or preventing the formations of chlorophyll or the green colouring matter. The formation of the acrid or bitter principle is also prevented, as is shown in the blanching of celery and sea kale.

ALBUMEN. (Vol. I. p. 42.) *The adulteration of.* (*Albumine*, Fr.; *Das Albumin*, Ger.) Albumen is often adulterated with starch and gum. To detect these the suspected albumen is dissolved in warm water. After resting some time, the mixture is stirred. If white clots float about, it shows that the albumen has been coagulated by the employment of too much heat. If, when acetic acid is added to the mixture, a precipitate is formed, gum is present. Starch is detected by adding iodine to the solution, which gives a blue black colour. The presence of sugar is determined by the usual tests.

ALBUMEN OF BLOOD. This variety of albumen is being more used than that of egg.

To obtain it.—The blood is collected in a circular flat-bottomed basin, with perpendicular sides. It is allowed to stand for about 6 hours. The serum is first decanted into a filter, and received in a vessel having a hole in the bottom of it, fitted with a cork, through which a glass tube passes up above the liquid. When the upper portion becomes quite clear, the tube is drawn down into the fluid, and the clear serum drawn off. The clear serum is evaporated by a gentle heat, and may be used instead of egg albumen. The clot is next put on the filter, and cut into small pieces. The serum running through is treated as before, and is used, when evaporated to dryness, for fixing dark and heavy shades. The blood of 5 oxen yields 2 lb. of dry albumen; that of 20 sheep or 34 calves about the same quantity.

ALCOHOL. (Vol. I. p. 42.) (*Alcool*, Fr.; *Der Alkohol*, Ger.) If a cobalt salt be added to an alcoholic solution of sulphocyanide of ammonium, a deep blue colouration is produced, which suddenly vanishes on dilution with water, and reappears on further addition of alcohol. Given the same volume, spirit of a certain percentage always gives precisely the same intensity of colour with a standard blue solution, in whichever order alcohol or water may be added. It is possible in this way to determine quickly by a volumetric process even so little as one-fourth per cent. of alcohol in a mixture. A measured quantity of the dark blue standard fluid is placed in a cylinder, and the mixture to be tested is added until the colour is reduced to that of a strip of pale blue glass; the volume of this pale coloured fluid will be the greater as the mixture is richer in alcohol. This volume, once determined, will always remain the same, and the percentage noted on a graduated cylinder may afterwards be read off without further trouble. The standard fluid is always prepared with spirit of the same strength, and compared with the same strip of glass. The nitrate of cobalt is the salt found most convenient for this purpose: *coloured brandy* may be tested directly—in this case the tint is not blue, however, but green. Two cylinders are therefore necessary, one for the test, and one to give the desired tint in conjunction with the blue glass. The cobalt solution may be either neutral or slightly acid, but should contain as little water as possible.—*Zeitschrift des Österreich Apoth.* ver 1876.

ALCOHOLOMETRY (Vol. I. p. 68), and **ALCOHOL** (Vol. i. p. 42.) M. E. J. Maumené published in the *Annales des Chimie* for January 1877, a 'Mémoire sur la Nouvelle Méthode Alcoométrique par la Distillation des Spiritueux Alcalisés,' in which he expresses his firm belief in the process of M. Gay-Lussac, in opposition to the conclusions of a report presented to the Academy of Sciences, advocating the use of the ébullioscope of Vidal-Malligand.

M. E. J. Maumené is well known by his previous works on alcoholometry, which have displayed a great amount of precision and considerable powers of research. He says:—

'I do not wish to discuss the conclusions of this report: I only wish to show the motive for new researches on the standard (titrage) of wines by distillation, a process advised in 1823 by one of the most illustrious members of the Academy, Gay-Lussac, and employed everywhere since then as a very certain and precise method. If I may be permitted to speak of myself, I have preserved for the method of Gay-Lussac's a confidence, founded on innumerable analyses, of which a great number of cases have received confirmation, both direct and indirect; and I have recommended this method as the best in the two editions of my 'Traité théorique et practique du travail des vins.' It appears to me a duty towards science and towards the public to study the titration of alcohol by distillation, and to measure more strictly

than has yet been done, the influences capable of introducing error into this method.

I immediately set to work, and the results obtained being of a nature to interest the Academy and the public, I hasten to submit them to their judgment.'

M. E. J. Maumené modifies Gay-Lussac's mode of estimating alcohol as follows:—

He distils to one half 200 c.c. of the spirituous liquid (containing not more than 15 per cent. of alcohol) measured at 15° C., and rendered slightly alkaline with caustic soda. The alcohol in the distillate at 15° is determined by a good centigrade alcoholometer. If the distillate should contain an appreciable quantity of ammonia, it is neutralised with a few drops of sulphuric acid, and re-distilled. Alcohol may be estimated to within ·05 per cent.

The method of Gay-Lussac is by a complete elimination of all the products contained with the alcohol in the wines, and a perfect isolation of the alcohol in the first products of distillation; or, if greater exactness is required, an isolation of all the alcohol, accompanied with a certain quantity of pure water.

When the wines are not rich, not above 0·11 to 0·12 of alcohol in volume, the illustrious chemist produces this isolation in the first third distilled; when the wines contain more alcohol, it is well to push the distillation to half; but, with this precaution, the distilled liquid contains all the alcohol of the original liquid. This alcohol is only mixed with pure water, and the alcoholometer will immediately indicate the quantity, if the temperature of the mixture is +15°. For other temperatures, a correction must be made of the tables arranged by Gay-Lussac and Collardeau.

For a long time Gay-Lussac's method has fulfilled the end proposed in the manufacture, and even in the laboratory, without any complaint. His exactness was considered to have attained to ⅕th of a degree, and it gave the contents of alcohol to 0·01. Lately this has not appeared sufficiently evident, and the Report made to the Academy shows a preference for the Vidal-Malligand ébullioscope, which directly ascertains the strength of hydrated alcohol by its boiling point. The causes of this deserve to be carefully examined.

In the study of wines it is easy to recognise the presence of other matters as volatile as the ordinary alcohol, $C^4H^6O^2$. There is found—

1st. Of other alcohols: the propylic, butylic amylic alcohols, &c.

2nd. Ethers, the presence of which has not been shown directly, but indirectly by synthetical assays, of which M. Maumené made known the results to the Academy, and which M. Dumas affirms, agree with his own experiments.

3rd. Ethylic aldehyde, and perhaps other equivalents.

4th. Volatile acids, in the first rank of which figure acetic acid, and the propylic or propionic acids, &c. These acids are liquid at the ordinary temperature. There exists in wines, often in large quantities, a well-known gaseous acid,—carbonic acid,—which is inseparable from alcohol in the vinous fermentation, and which possesses peculiar importance. This has been shown in the treatise of 1874, already referred to.

M. Maumené examines with great care the influences of alcohols, of ethers, of aldehydes, and of acids upon various combinations, and tests the merits of the process by fractional distillation, and by the ébullioscope of Vidal-Malligand. Numerous tables are given, of which one or two may be quoted as examples.

Wine of Carcassonne retailed at 1 franc 60 centimes in Paris.

Fractions of 50cc of products of distillation	Densities to +15°	Alcoholic richness	Acidity in acetic acid $C^4H^4O^4$ (per litre)
1	0,92905	55	0,540
2	94450	44,5	1,067
3	96120	33,67	1,173
4	97190	21,2	1,387
5	98230	14,0	1,493
6	98850	8,5	1,544
7	99487	3,5	1,589
8	99750	1,67	1,652
9	99950	0,32	1,733
10	99986	0,01	1,813
11	1,00012	„	1,920
12	„	„	2,006
13	„	„	2,134
14	„	„	2,572

Wine from the neighbourhood of Chagny (Bourgogne) at 1 franc 20 centimes the litre in Paris.

Fractions of 50cc of products of distillation	Densities at +15°	Alcoholic strength	Acidity in acetic acid $C^2H^4O^2$ (per litre)
			gr.
1	0,92074	56,03	0,820
2	93982	47,32	0,947
3	95703	36,76	1,036
4	96986	26,85	1,098
5	98023	15,97	1,100
6	98901	7,92	1,143
7	99422	3,98	1,164
8	99752	1,67	1,185
9	99941	0,39	1,202
10	99992	0,05	1,218
11	1,00011	..	1,254
12	..	..	1,296
13	..	..	1,340
14	..	..	1,385
15	..	..	1,434
16	..	..	1,482
17	..	..	1,524
18	..	..	1,567
19	..	..	1,614

Several similar tables are given, for which we must refer to the Memoir itself. A general summary of the results will be found in the following table:—

Number of experiment	Nature of wine	Alcoholic strength		Diminution due to acid
1	Red, Carcassonne	9,83		0,1779
2	Id. Chagny . . .	10,78		0,4311
3	Id. Podensac . .	9,79		0,4053
4	Id. commercial (Paris) .	10,31		0,2123
5	Id. Chagny, iced . .	12,15		0,2057
6	White of commerce . .	10,14		0,6881
7	Id. Chablis . . .	10,26		0,5114
8	The same (oxygenised) .	7,87		2,1663
9	White, Bouzy . .	12,76		neglected
10	Id. Verzenay	11,75		id.
11	Id. Rilly . .	11,02		id.
12	Liquid diluted alcohol .	10		..
13	Id. . . .	20		..
14	Id. . . .	25		..
15	Id. . . .	30		..
16	Id. and wine .	13,0		..
17	Id. . . .	10	saturation of CO^2	(not acid)
18	Id. . .	20 et 30	id.	(id.)
19	Id. . .	10	id.	..
20	Wine of molasses	6,27		0,6035

In vol. i. p. 51 a set of tables is given by M. GAY-LUSSAC, showing the alcoholometrical strength of spirituous liquors. The following table, by M. MAUMENÉ, is an appropriate supplement to those tables:—

Composition of mixtures of Alcohol and Water at the temperature of + 15° C. (60° F.)

Density of mixture at + 15°		Alcohol			Water by weight		Contraction for 1 volume contracted $\frac{D'}{D}-1$
		By weight		In volume			
Referred to that of water at 15°	In grams or weight of 1 litre of 1·760 pint	In 1 litre 1·760 pint	In 1 kilogr. 2·204 lbs.	Degree alcoholometric	In 1 litre	In 1 kilogr.	
	gr.	gr.	gr.	gr.	gr.	gr.	cc.
10000	999,150	0,000	0,000	0	999,150	1000,000	0,000
9985	997,651	7,982	8,001	1	989,649	991,999	0,526
9970	996,153	15,869	15,950	2	980,284	984,050	1,071
9956	994,734	23,863	23,989	3	970,871	976,011	1,787
9942	993,335	31,836	32,050	4	961,499	967,950	2,397
9929	992,036	39,825	40,145	5	952,211	959,855	3,162
9916	990,658	47,827	48,278	6	942,841	951,722	3,930
9903	989,438	55,841	56,437	7	933,597	943,563	4,700
9891	988,240	63,874	64,634	8	924,366	935,366	5,571
9878	986,940	71,914	72,865	9	915,026	927,135	6,353
9866	985,741	79,980	81,137	10	905,761	918,863	7,304
9855	984,642	88,059	89,432	11	896,583	910,568	8,227
9843	983,444	96,149	98,219	12	887,295	901,781	9,118
9833	982,444	104,275	106,138	13	878,169	893,862	10,219
9822	981,345	112,666	114,898	14	868,679	885,102	11,220
9812	980,346	120,569	122,986	15	859,776	877,014	12,330
9802	979,347	128,749	131,462	16	850,598	868,538	13,444
9792	978,348	136,953	139,976	17	841,395	860,024	14,663
9782	977,349	145,161	148,525	18	832,188	851,475	15,686
9773	976,450	153,413	157,113	19	823,037	842,887	16,919
9762	975,552	161,867	166,753	20	813,686	834,247	18,053
9753	974,451	169,957	174,413	21	804,494	825,587	19,295
9742	973,352	178,232	183,112	22	795,120	816,888	20,355
9732	972,353	186,543	191,847	23	785,810	808,153	21,482
9721	971,254	194,853	200,620	24	776,401	799,380	22,530
9711	970,255	203,202	209,432	25	767,053	790,568	23,685
9700	969,156	211,548	218,282	26	757,608	781,718	24,745
9690	968,157	219,935	227,169	27	748,222	772,831	25,912
9679	967,058	228,318	236,150	28	738,740	763,850	26,979
9668	965,959	236,719	245,061	29	729,240	754,939	28,051
9657	964,860	245,138	254,066	30	719,722	745,934	29,127
9645	963,661	253,549	263,110	31	710,112	736,890	30,100
9633	962,462	261,976	272,184	32	700,485	727,816	30,979
9621	961,263	270,421	281,318	33	690,842	718,682	32,061
9608	959,964	278,852	290,482	34	681,112	709,518	32,946
9594	958,565	287,270	299,667	35	671,295	700,333	33,716
9579	957,166	295,700	308,933	36	661,466	691,067	34,494
9567	955,868	304,175	318,219	37	651,693	681,781	35,420
9553	954,469	312,633	327,547	38	641,836	672,453	36,170
9538	952,970	321,071	336,916	39	631,899	663,084	36,851
9523	951,471	329,521	346,328	40	621,950	653,672	37,730
9507	949,973	337,982	355,781	41	611,991	644,219	38,220
9491	948,274	346,383	365,277	42	601,891	634,723	38,692
9474	946,576	354,792	374,816	43	591,784	625,184	39,165
9457	944,877	363,209	384,398	44	581,668	615,602	39,642
9440	943,179	371,634	394,023	45	571,545	605,977	40,117
9422	941,380	380,027	403,691	46	561,353	596,309	40,388
9404	939,482	388,385	413,403	47	551,097	586,597	40,745
9385	937,683	396,790	423,160	48	540,894	576,840	41,115
9367	935,885	405,202	432,962	49	530,683	567,038	41,450
9348	933,987	413,576	442,807	50	520,411	557,193	41,753
9329	932,088	421,955	452,698	51	510,133	547,302	41,918

Density of mixture at +15°		Alcohol			Water by weight		Contraction for 1 volume contracted $\frac{V'}{V}-1$
Referred to that of water at 15°	In grams or weight of 1 litre or 1·760 pint	By weight: In 1 litre 1·760 pint	By weight: In 1 kilogr. 2·204 lbs.	In volume: Degree of alcoholometric	In 1 litre	In 1 kilogr.	
	gr.	gr.	gr.	gr.	gr.	gr.	cc.
9300	930,090	430,292	462,655	52	499,798	537,345	42,173
9282	928,092	438,632	472,617	53	489,460	527,383	42,327
9265	925,994	446,927	482,640	54	479,067	517,360	42,370
9248	923,995	455,271	492,720	55	468,724	507,280	42,525
9227	921,997	463,568	502,842	56	458,429	497,158	42,563
9206	919,799	471,806	513,010	57	447,993	486,990	42,615
9185	917,701	480,164	523,225	58	437,537	476,775	42,657
9163	915,603	488,411	533,431	59	427,192	466,569	42,561
9141	913,305	496,656	543,801	60	416,649	456,199	42,520
9118	911,007	501,809	554,221	61	409,198	445,779	42,468
9096	908,809	512,085	564,569	62	396,724	435,431	42,263
9072	906,411	521,267	575,090	63	385,144	424,910	42,070
9049	904,213	529,446	585,532	64	374,767	414,468	41,868
9027	901,914	537,623	596,090	65	364,291	403,910	41,701
9003	899,517	545,793	606,764	66	353,724	393,236	41,512
8980	897,219	553,901	617,353	67	343,318	382,647	41,290
8956	894,821	562,002	628,061	68	332,819	371,939	40,899
8931	892,323	570,098	638,892	69	322,225	361,108	40,591
8907	889,923	578,122	649,630	70	311,801	350,370	40,160
8882	887,427	586,139	660,493	71	301,288	339,507	39,733
8856	884,830	594,082	671,408	72	290,748	328,592	39,151
8831	882,332	602,081	682,375	73	280,251	317,625	38,751
8805	879,734	610,706	694,194	74	269,028	305,806	38,198
8779	877,130	617,910	704,470	75	259,220	295,530	37,642
8752	874,439	625,745	715,597	76	248,694	284,403	36,963
8726	871,841	633,635	726,778	77	238,206	273,222	36,401
8699	869,143	641,440	738,014	78	227,703	261,986	35,716
8671	866,345	649,158	749,306	79	217,187	250,694	34,919
8645	863,716	657,012	760,653	80	206,704	239,347	34,297
8617	860,950	664,778	772,144	81	196,172	227,856	33,641
8589	858,153	672,453	783,605	82	185,700	216,395	32,827
8560	855,255	680,032	795,122	83	175,223	204,878	31,884
8531	852,358	687,593	806,696	84	164,765	193,304	30,930
8502	849,460	695,137	818,328	85	154,323	181,672	29,985
8472	846,463	702,479	830,017	86	143,984	169,983	29,007
8442	843,465	709,999	841,764	87	133,466	158,236	27,822
8411	840,368	717,314	853,571	88	123,054	146,429	26,611
8379	837,171	724,667	865,543	89	112,504	134,457	25,307
8346	833,874	731,609	877,302	90	102,265	122,698	23,802
8312	830,477	738,582	889,346	91	91,895	110,654	22,301
8277	826,980	745,434	901,393	92	81,546	98,607	20,471
8241	823,483	752,249	913,497	93	71,234	86,503	18,729
8205	819,786	758,849	925,667	94	60,937	74,333	16,733
8167	815,990	765,314	937,897	95	50,676	62,103	14,602
8126	812,093	771,642	950,189	96	40,451	49,811	12,334
8086	807,896	777,637	962,545	97	30,259	37,455	9,682
8040	803,400	783,284	974,961	98	20,116	25,039	6,627
7995	798,801	789,762	988,680	99	9,039	11,320	3,460
7947	794,700	794,700	1000,000	100	0,000	0,000	0,000

M. Maumené concludes his valuable Memoir by giving the results obtained by his method and by the ébullioscope, which we copy on the following page.

Number	Kind of wine or spirit	Method of [illegible]	Ébullioscope of Vidal-Malligand	
1	Red wine, Carcassonne	9,62	9,95	+ 0,33
2	Id. Chagny	10,76	10,76	+ 0,49
3	Id. Podensac	9,88	9,55	+ 0,37
4	Id. commerce (Paris)	10,42	10,05	− 0,37
5	Id. Chagny, iced	12,25	11,70	− 0,55
6	White wine, commerce (Paris)	10,14	10,45	+ 0,31
7	Id. Chablis	10,41	10,40	+ 0,09
8	Id. Chablis (oxidised)	7,82	7,95	+ 0,13
9	Id. Bouzy	12,72	13,10	+ 0,38
10	Id. Verzenay	11,74	11,15	− 0,59
11	Id. Rilly	11,51	11,00	− 0,51
12	Alcohol and water	10,12	9,75	− 0,37
13	Id.	20	20,65	+ 0,65
14	Id.	25	24,10	− 0,90
15	Id.	30	30,60 (15,30 × 2)	+ 0,60
16	Id. and wine	13,94	13,50	− 0,44
17	Id.	10,22	10,00	− 0,22
18	Id.	20,04	20,50	+ 0,46
		30,08	30,60 (15,30 × 2)	+ 0,52
19	Wine of molasses	6,24	5,30	− 0,94
20	Id.	10,06	10,00	− 0,06

The value of the two methods will be fully understood by a careful examination of these conditions.—*Annales de Chimie et de Physique.*

Detection of vinic alcohol in mixtures, and especially in presence of wood spirit. MM. A. Riche and C. Bardy. See Dr. Ure's 'Method for detecting wood spirit in alcohol,' vol. i. p. 65.

The method of the authors depends on the following principles:—Aldehyde turn the red colour of the salts of rosaniline to a violet. Methyle and acetal possess the same property. This colour resists the action of sulphurous acid, which readily discharges magenta. If the liquid does not mark 80° on the alcoholometer,—the case with all commercial alcohols,—4 c.c. are poured into the body of a small retort, and 6 c.c., of ordinary sulphuric acid are then carefully added. After having warmed the apparatus for an instant, 10 c.c. of water are added, the apparatus is stoppered and heated, and 7 to 8 c.c. are allowed to distil over into a graduated test-tube, in which have been put 10 c.c. of water. Into the test-tube 5 c.c. of sulphuric acid at 21° B. are poured, and 20 c.c. solution of permanganate of potash at 4° B. After from three to five minutes, the liquid will have become decidedly brown, and 4 c.c. of hyposulphite of soda at 33° B. are added, and then the same measure of a solution of magenta of 2 centigrams per litre. If the liquid in question marks less than 80°, it is diluted with water down to 5°, and 30 c.c. are taken and distilled with 10 c.c. of sulphuric acid, and 12 c.c. are collected and mixed successively with 4 c.c. of acid and the other reagents in the proportions given above. Under these circumstances, wood spirit gives a yellowish white liquid; whilst if it is accompanied by vinic alcohol, the liquid takes a violet colouration, the more intense in proportion to the quantity of alcohol. The operation requires only a few minutes, and the test-tube is marked, so as to indicate the quantities of the reagents to be introduced. Acetone formic acid, and isopropylic alcohol, do not give a colouration under these circumstances.

But the case is different with the propylic, butylic, and amylic alcohols. This is not of practical importance, because these alcohols are not found in commerce in a separate state, and only occur in vinic alcohol. In this case, however, the authors lower the alcohol to 5°, and treat successively with 5 c.c. of acid, 5 c.c. of permanganate, 2 c.c. of hyposulphite, and 4 c.c. of magenta. The methylic, butylic, and amylic alcohols yield a sulphur yellow solution, the propylic gives a greenish grey tint, whilst vinic alcohol produces a purple colouration.—*Chemical News,* April 28.

ALDER-BARK. (See Alder, vol. i. p. 66.)

This bark contains a colouring principle combined with its tannin. The bark is well boiled in soft water, and scrap iron added, which is allowed to act for some time. The blacks produced are said to be very rich and permanent.

With tin and alumina, the colouring matter of the alder yields a variety of buffs, yellow, brown, and orange shades.

ALFA FIBRE. (The fibre of *Macrochloa tenacissima*). The most important of the vegetable productions of Algeria. It grows spontaneously over vast tracts of country, where cultivation of any description is impossible. 10,000,000 acres are covered with this plant, from which a quantity of paper-making material may be collected, equal to three-fourths of all the rags sold and used throughout the world. The exportation of alfa, which in 1869 amounted to 4,000 tons, and in 1870 to 32,000 tons, amounted in 1873 to 45,769 tons; in 1874 it reached 55,000 tons, and in 1875 exceeded 60,000 tons.

ALGÆ, *Fresh water.* (Vol. i. p. 67.) The *Cladophora glomerata* appears to be a source of iodine and bromine which has been neglected.

Jessler found in 100 cwt. of the ash of this plant 21·6 grams of iodine, and 8·5 grams of bromine. The plant analysed by Jessler grew in an ordinary stream of water. H. Zenger analysed other plants which grew in water, containing a large quantity of lime, with like result. Stenhouse and others assert that all those algæ which grow in a soil rich in common salt contain iodine and bromine. Sprengel found both these in another freshwater plant, *Lemna minor.*—H. Zenger, *Arch. Pharm.*

ALIZARATES. Several alizarates can be formed by the decomposition of the ammonium salt.

Almost all other salts can be obtained by double decomposition from a nearly saturated alkaline or ammoniacal solution of alizarin, with the corresponding soluble metallic compounds. The following table, given by Auerbach, shows the colour of the different metallic alizarates as precipitated:—

Chloride of strontium	Violet, *slightly reddish*
Sulphate of magnesia	Bluish violet
Chloride of magnesium	Dark violet
Chloride of iron (ferrous)	Blackish violet
Do. do. (ferric)	Brown black
Chloride of chromium	Brownish violet
Sulphate of copper	Brownish red violet
Basic acetate of lead	Violet, *slightly brownish*
Nitrate of mercury	Dark violet black
Chloride of mercury	Dark violet
Ammonio-chloride of copper	Deep violet
Tartar emetic	Reddish yellow violet
Chloride of tin (stannous)	Reddish violet
Do. do. (stannic)	Pure violet.

ALIZARATE OF AMMONIUM. The transformation of alizarin by means of ammonia has been examined by Schützenberger and Paraf. That of purpurin by Stenhouse and Schützenberger. To obtain accurate results, it is needful above all things to set out with a pure alizarin. Liebermann and Troschke acted upon alizarin with ammonia at temperatures between 150° and 200°. If concentrated solutions are employed, only a single product is formed by the reaction. This is precipitated in reddish-brown flocks on the addition of acids to the purple solution. This compound is formed in accordance with the equation:

$$C^{14}H^{8}O^{4} + NH^{3} = C^{14}H^{7} . NH^{2} . O^{3} + H^{2}O.$$

ALIZARIN. (Vol. i. p. 70.) *Alizarine.* (*Alizarine*, Fr.; *Das Alizarin*, Ger.) In addition to what has been said in the volume referred to, a brief history of the discovery of the artificial product, mainly derived from Auerbach, will be of interest, and will complete the history of the chemical researches given.

The earliest chemical researches on the madder root are due to Watt, Bucholz, Hausmann, Kuhlmann, &c. In 1826 Colin and Robiquet obtained alizarin and purpurin, the former in a state of purity. The name 'alizarin' was taken from *Alizari*, the commercial name for madder root imported from the Levant. The colouring matter was first named 'matière colorante rouge' by Gaultier de Claubry and Persoz, 'madder red' by Runge, and 'lizaric acid' by Debus.

Robiquet was the first who analysed alizarin, and obtained numbers which agree with the formula $C^{14}H^{8}O^{4}$, as now received if calculated on the correct atomic weight of carbon. Schiel in 1846 gave the formula of alizarin as $C^{20}H^{6}O^{6}$, and Debus in 1848 made it $C^{10}H^{8}O^{3}$. Schunck adopted the formula $C^{14}H^{10}O^{4}$, although his results agree better with $C^{14}H^{8}O^{4}$. Shortly afterwards, in 1849, Gerhardt drew attention to the similarity between alizaric acid and phthalic acid, $C^{8}H^{6}O^{4}$, and pronounced the two identical, on the ground of certain qualitative experiments. This view was afterwards confirmed by the analyses and comparisons of Wolff and Strecker. They

thus arrived at the conclusion, that alizarin and chloroxynaphthalic acid, $C^{10}H^5ClO^3$, which likewise yields phthalic acid on oxidation, are closely related; and they pointed out the great similarity of the two in their physical properties. In consequence of this view, they assigned to alizarin the formula $C^{10}H^6O^3$.

Latterly SCHÜTZENBERGER and PARAF, relying upon their examination of a compound of ammonia and alizarin, proposed to double the formula, and assume it as $C^{20}H^{12}O^6$. BOLLEY and ROSA proposed the formula $C^{20}H^{13}O^6$, which was, however, rejected on account of the uneven number of the atoms of hydrogen. The first who arrived at the correct formula was STRECKER. He proposed the formula $C^{14}H^8O^4$, and this was confirmed by the reduction of alizarin to anthracen effected by GRAEBE and LIEBERMANN as already stated. Vol. I. p. 70.

The manufacture of alizarin was long checked for want of the raw material, since *anthracen*, which is converted first into anthrachinon and then into alizarin, is found, to a small extent only, in coal tar.

They now obtain the raw material in quantity. Phthalic acid, $C^8H^6O^4$, is produced by oxidising naphthalin. Benzol, C^6H^6, is an abundant constituent of coal tar. If the chlorine compound of phthalic acid, $C^8H^4O^2Cl^2$, is heated for 12 hours with benzol to 220° C. in a closed vessel, anthrachinon is obtained according to the following reaction:—

$$\underbrace{C^8H^4O^2Cl2}_{\text{Phthalic chloride.}} + \underbrace{C^6H^6}_{\text{Benzol.}} = \underbrace{C^{14}H^8O^2}_{\text{Anthrachinon.}} + \underbrace{2\,HCl}_{\text{Hydrochloric acid.}}$$

This process is one of PICCARD'S.—REIMANN'S *Färber Zeitung*, No. 4, 1875.

According to ROCHLEDER, morindone, the substance obtained by the decomposition of morindin by heat, is identical with alizarin. This view is corroborated by STENHOUSE, who suggests *Morinda citrifolia* as the best source of alizarin, as it contains that substance free from purpurin. STEIN denies this identity, *Ann. Ch. Pharm.* lxxxii., *Chemical Society's Journal*, *Jour. p. Chem.* xcvii.

Alizarin may be separated from purpurin by passing a jet of steam into water containing madder in suspension at such a rate as to keep the temperature constantly at 55°, never allowing it to rise higher, and repeating this treatment till the wash waters run off quite colourless (purpurin dissolves in water at from 25° to 55°, whereas alizarin begins to dissolve only at 75°). On adding baryta water to these waters, purpurin is precipitated in the form of a lake. Madder thus treated yields from 2 to 3 per cent. of purpurin, and 4 to 4½ per cent. of alizarin.—LEITENBERGER, *Bull. Soc. Chim.* x. See also WATTS'S *Dictionary of Chemistry* for MORINDONE.

Part played by Acids in dyeing with Alizarin and its congeners. M. A. ROSENSTIEHL.—The author has shown in a former paper that the best results are obtained in dyeing with alizarin and purpurin by adding to the baths equal equivalents of these substances, and of lime in the state of soluble bicarbonate. In continuing his researches, he has discovered further facts relating to the chemical function of these tinctorial bodies. If a dye bath is made up of water containing bicarbonate of lime, as the temperature rises there is produced a chemical action between this salt and the colouring matter, the result of which is the formation of an insoluble lime lake, which takes no part in the process of dyeing. Comparative trials have shown that in the best conditions the loss is one-fifth of the colouring matter. In the paper referred to it was shown that carbonic acid rapidly decomposes the alizarin lime lake—that it acts more slowly upon that of purpurin; but that it, by its presence, very much retards the formation of the latter lake. It results from this observation that the loss may be avoided by passing into the bath a continuous current of carbonic acid. Experiment confirmed this; in the presence of carbonic acid the formation of lime lakes is prevented, the bath can be totally exhausted, and the colours obtained are notably more intense. After having proved the good effect of carbonic acid on the small scale, ROSENSTIEHL repeated his experiments on quantities from 100 to 200 times larger, so as to approach the conditions of industrial operations. He dyed pieces of 25 mètres in 50 litres of water. The result of these experiments was very different from that obtained on the small scale. No useful effect resulted from the employment of carbonic acid, except the quantity of carbonate of lime was decidedly large. Hence the author concludes that in operation on the large scale the same losses are not experienced as on the small, although in the two cases the same colouring matters are used in the same proportions and in identical conditions of temperature. The cause of this remarkable discrepancy lies in the mass of carbonic acid naturally dissolved in the water, which proves an obstacle to the formation of calcareous lakes. It is soon expelled from the small volume of water used in laboratory experiments, whilst a longer time is required for its escape from a large volume of water. Therefore the dyeing may be completed and

the bath be exhausted before all the gas has escaped into the air. This explains a fact familiar to practical men, the cause of which was unknown: it is impossible to execute several successive dyeings in the same bath, even if it is re-set with chalk and tinctorial matter. The carbonic acid has partly escaped during the first operation, and what remains is not sufficient for a new operation. Hence this gas, as naturally dissolved in the water, plays an important part. Rosenstiehl then made a series of experiments with several salts of lime, and found that acetate of lime and acetic acid may advantageously replace the carbonate and carbonic acid. During the operation the mordanted tissue laid hold at once of the lime and of the colouring matter. The acetic acid is set at liberty, and evaporates in the water or accumulates in the bath without at all injuring the saturation of the mordants, which is thus easily effected in an acid medium. He has tried the action of this salt on various colouring matters of madder, on the extracts, and on artificial alizarin, and found that it precipitates none of them, if we do not overstep the proportion of two equivalents of acetate to one of colouring matter, and take care to acidify the bath from the beginning. The colours come out of this bath perfectly saturated; the bath is perfectly exhausted, and is, after dyeing, more limpid than if carbonic acid had been used. The same beneficial results were observed on the large scale. The advantages of this method are evident: it is no longer necessary to exhaust the bath at once, and we may dye in presence of an excess of colouring matter, working at a lower temperature and in less time.

ALIZARIN, *The Nitro-derivatives of. Monacetyl alizarin.*—On boiling alizarin for several hours with acetic anhydride in excess it was gradually acted upon, and after a time the mixture became a crystalline mass. The boiling being continued for about a day, so that no unchanged alizarin might remain, the product was allowed to crystallise. As the solution cooled, bright golden scales were deposited, but afterwards groups of primrose yellow crystals. These two bodies were carefully separated—the primrose yellow crystals were monacetyl alizarin, and the golden scales were *Diacetyl alizarin*, which may be formed by simply boiling alizarin with considerable excess of acetic anhydride.

Nitro-alizarin.—Diacetyl alizarin in fine powder was gradually added to nitric acid, spec. grav. 1·5, cooled with ice; it dissolved, and the acid became the colour of bromine. This solution, when added to a large excess of water, deposited a yellow precipitate, which was collected, well washed with cold water, and, when free from acid, boiled in water, to dissolve out a small quantity of an orange-coloured secondary product. The insoluble residue was dissolved in hot dilute caustic potash, with which it formed a blue violet solution, and was then acidified with hydrochloric acid, when a copious yellow precipitate separated: this was washed, dried, and crystallised several times from alcohol. Nitro-alizarin crystallises from alcohol or glacial acetic acid in beautiful yellow needles. It dissolves in caustic alkali with a very blue violet colour, if anything bluer than that of alizarin; but if only a minute quantity of alkali is employed, the solution is of a beautiful crimson colour. Its solution in ammonia is also violet.

When oxidised with nitric acid it produces a crystalline acid, which is apparently phthalic acid.

Amido-alizarin.—Nitro-alizarin is rapidly changed by the influence of reducing agents. By boiling its potassic solution with granulated tin, its colour quickly changes to a beautiful red, after which it becomes orange red. This is amido-alizarin. It dissolves in alcohol, but not very freely, producing a beautiful crimson solution slightly fluorescent: alkalies likewise dissolve it, forming crimson solutions. When boiled with sulphate of alumina it gives a beautiful purple solution, from which ammonia precipitates a purple red lake.

These colouring matters possess the power of dyeing ordinary madder mordants. Nitro-alizarin gives, with alumina mordants, very clear orange red colours, not unlike some of the colours produced with aurin, and with iron mordants reddish purple colours. The use of a small percentage of carbonate of lime in the dye bath is very useful in dyeing with this substance.

Amidalizarin gives with alumina mordants purple colours, and with iron a bluish or steel-like colour.

These colouring matters also dye silk without the use of mordants, the former giving a golden yellow, and the latter a good crimson colour. 'On Acetyl- and Nitro-Derivatives of Alizarin,' by W. H. Perkin, F.R.S. *Journal of the Chemical Society*, 1876, Vol. II.

ALIZARIN, GREEN (*Alizarine verte*, Fr.), was first prepared by Professor C. Koff, and depends upon the different action of sulphurous acid upon the glucosides in alizarin and purpurin. To prepare green alizarin, madder is mixed with 10 parts of aqueous sulphuric acid, to which a little hydrochloric acid is added to decompose

the lime salts present. The mixture is poured into a well covered wooden vessel, and allowed to stand from 12 to 24 hours with occasional stirring. The semifluid mass is put upon a filter bag; the bottoms of the cask are rinsed into the bag with a little water; the whole is allowed to drain, and the bag is submitted to a gradual but powerful pressure. The liquid is placed in a wooden vessel. The pressed mass is again treated with 10 parts of sulphurous acid, and the filtrated and expressed liquids are added to the first lot. The pressed residue is thus treated for the third time. The liquid has a bright orange colour, with a brownish cast if highly concentrated. This can be preserved at common temperatures for any length of time in closed vessels. If heated, it undergoes a remarkable change. Green alizarin is completely precipitated in from 24 to 36 hours, which is facilitated by gentle shaking.—*Anthracen, &c.*, by G. Auerbach. Translated by William Crookes, F.R.S.

ALKALI MANUFACTURE. (Vol. i. p. 70; Alkali, vol. iii.; Potash, vol. iii. p. 591; Soda, vol. iii. pp. 853–4, &c.)

In the previous volume the alkali manufacture is treated under the heads referred to. The improvements which have been made, and which it is desirable to mention, have so much in common, that it is considered advantageous to introduce the consideration of them under one general head. At p. 851, vol. iii., the decomposing process is considered. Amongst the most recent improvements is the introduction of the new decomposing furnace of Jones and Walsh, which is well described by Mr. R. C. Clapham, from whose paper we extract the following:—

'The best methods of decomposing salt with sulphuric acid have long attracted the attention of manufacturers, for it is admitted on all sides that those adopted hitherto in practice have been unsatisfactory, leading to expenses from partial stoppage of the work, breakage of pans, and loss of sulphuric acid.

'When the present system of making soda was commenced on the Tyne in 1820 (at that time called the French system), the chemical trade was very limited, and small lead pans lined with brickwork were used in decomposing salt. A charge of 2 cwt. of salt was taken, the sulphuric acid was slowly poured upon it from a carboy, through a hole in the top of the furnace, and it took three hours to complete the operation. But as these lead pans were so liable to be injured, a fire brick furnace was substituted in 1828, which was looked upon then as an improvement, and was well known locally as the "Dandy" furnace. At that time no attempt was made at the condensation of the hydrochloric acid fumes, and they passed directly into the atmosphere. A great improvement upon the above was introduced in 1840, by the late Mr. John Lee, who applied a metal pan about the same size as we now use, and its adoption by the trade has led, amongst other advantages, to a large saving in sulphuric acid. This pan has, however, been always liable to frequent breakage from negligence of workmen and other causes, and to get over this difficulty various substitutes have at times been tried. In 1860 I had some fire-clay pans made at the Scotswood Brick Works, which were used at the Walker Alkali Works. They were found to work pretty well, but were given up from the difficulty of getting them properly heated.

'If we allow that the life of an ordinary decomposing pan is long enough to turn out 2,000 tons of salt (in a few cases it may be more, but many will know that in some cases 1,000 tons is a fair quantity), I calculate that on the Tyne alone not less than 6,000*l.* per annum is spent in renewal of decomposing pans; and if we take into account the loss of time caused by the breakages, the extra labour required, and the waste of acid, the money loss under these heads will be very considerable. In the face of these facts, there would then appear to be ample room for improvement. Messrs. William Jones and John Walsh, of Middlesborough, have contrived and erected a new class of decomposing furnace, which completes the whole charge of salt in one furnace. This furnace has now been at work several months, and from an examination of the plates forming the dish of a furnace which was laid off a few days ago, I found the plates to be as fresh and good as when erected.

'The furnace, which is now in actual work, and from which regular results have been obtained, consists of a metal dish, divided into six segments, all tightly fixed together. The metal is $2\frac{1}{2}$ inches thick, and the whole rests on solid brick-work. Its inside diameter is 15 ft., and the charge of salt is about 12 tons each 24 hours, so that a furnace of this capacity (allowance being made for draughts and local matters) will turn out about 80 tons of sulphate in six days. The batch is kept in constant motion by means of two metal arms, worked from a centre shaft, to which are fixed paddles and rakes, and the whole mass is much more completely mixed than in a hand-worked furnace, and the sulphate produced is of a fine and uniform character. The motion given to the crown wheel is got from a donkey engine, and an engine with a 6-inch cylinder is found to be sufficient to work the furnace. At present the

batch is both charged into the furnace and discharged by hand, but Mr. GOODMAN expects to perfect a plan to do this by machinery.

'The advantages to be derived from this new furnace may be described as a more regular daily plan of working; freedom from sudden stoppages by the breakage of the present pans; a direct saving in wages, as only one workman is required on each shift for charging and working the furnace; a saving of fuel, as the heat required is less than in the old furnace, and 3 cwt. of coke per ton of sulphate is used in the place of 9 cwt. of coal (= 5¼ cwt. coke) by the old furnace; a saving also of sulphuric acid calculated to be equal to 2 per cent. Then again, owing to the complete mixing and better working of the batch by machinery, a great inconvenience felt by the public living in the neighbourhood of chemical works, by the batches being sometimes drawn by the workmen in a partly finished state, and containing free hydrochloric acid, is entirely avoided. The fumes are emitted in a gradual and uniform manner throughout the working of the batch, and the condensation is, therefore, more perfect; and as the whole of the gas is passed through one coke tower, it is condensed into hydrochloric acid of 26° to 28° T.

'It therefore appears, that both in an economical and sanitary point of view, this furnace is an improvement on its predecessors. In the description I have given, I have purposely confined myself to a furnace in actual daily work, and from which known results have been obtained; but it is not unreasonable to expect that experience may show that a much larger weekly turn-out may be possible.

'Mr. JONES, following Mr. CLAPHAM, remarked that they were absolutely driven to use this furnace by the misconduct of that very low class of workmen, the decomposing men. They had their troubles at Middlesborough, as well as we on the Tyne had ours; and with the men constantly getting drunk and coming in and breaking the pots, it became at last a serious question whether they could not dispense with them altogether, and he made up his mind to endeavour to do so, even if it cost them more to do the work by mechanical means than by manual labour. This was their motive in trying this plan. Now, they found at first that continuing a few of these men to work the furnace, they had very great difficulty in getting it to work at all. By some mysterious means which they had not the means of ascertaining, the furnace perpetually went wrong at night; a cog broke, or the crown wheel gave way, or something or other went wrong; and they did not get to the end of that trouble until they had discharged every decomposing man from the place and got common labourers to do the work. Since then, they had got on very much better with the labour department. He might say that now the labour was done by one man—a strong, serviceable fellow who had been a cab-driver, and he drove the machine by day, and his mate by night; so that by means of one man each shift, they were now doing the work which formerly required three men—that was to say, they had a decomposing man at the pot, and of course they had a man at the roaster, and a man wheeling to the pot. Now, their one man does the whole of this work with the present machine. He wheels his own charges, he charges the machine, he minds it during the operation, and he discharges it; so that they would see that in those points there was a very considerable saving of labour; and the fact was, that at the present time they were simply paying this man—or rather these two men—who work the furnace at the rate of 1*d.* per cwt.; for that they did the whole of this work, and were earning nearly 3*l.* a week each; so that they were literally paid. There was no doubt that by quickening the process a little they could do better. They had not yet got quite all the satisfactory results they wished for; but by shortening the times of the charges, and getting a larger output, they would work the furnace considerably cheaper than they were doing. Their Mr. WALSH said he would not be satisfied until he got it done for ½*d.* a cwt. or 10*d.* a ton. He had not got it to that yet, but he had accomplished so much that he (Mr. JONES) did not doubt he would do it. As to the time of working the charges, they were at present working the furnace under a little want of draught; and therefore it had not yet quite fulfilled Mr. WALSH's expectations as to the amount of output; it was doing very little more than a smaller furnace which they had at work previously, and which had a better draught. But this was a mere mechanical matter, which could be put right in a few days. Then it would be a great point to save time and save fuel by getting the charges put in and withdrawn by mechanical means and a considerable saving could be effected in that way. Gentlemen would easily understand that a man could not throw five tons of stuff into anything with a shovel in a very short time. It took fully an hour—with a very good man indeed—to throw in five tons with a shovel; so that that hour is practically lost in charging a machine; and it took a still larger time to draw that charge out by hand. These were the two points which Mr. GOODMAN thought he would be able to improve upon very materially, and he (Mr. JONES) did not doubt it would be so. When these were added to the existing furnace, he was strongly of

opinion that it would turn out fully what Mr. CLAPHAM had stated in his paper that night, and perhaps more.'—*Transactions of the Newcastle-upon-Tyne Chemical Society*, March 1876.

Salt-cake.—Mr. GEORGE E. DAVIS gives the following analysis of salt-cake :—

	A	B	C
Insoluble in water	0·112	0·073	0·042
Free sulphuric acid	0·955	1·820	0·022
Sulphate of lime	1·139	1·148	1·046
Persulphate of iron	0·682	0·595	0·332
Chloride of sodium	2·632	0·234	0·744
Sulphate of sodium	94·383	96·137	97·824
Moisture	0·097	—	—

This is mixed with a certain quantity of limestone, with which clay or sand is often combined, to the disadvantage of the process. This is worked into a mixture, and charged into a reverberatory furnace, which will be understood by reference to the annexed *fig.*

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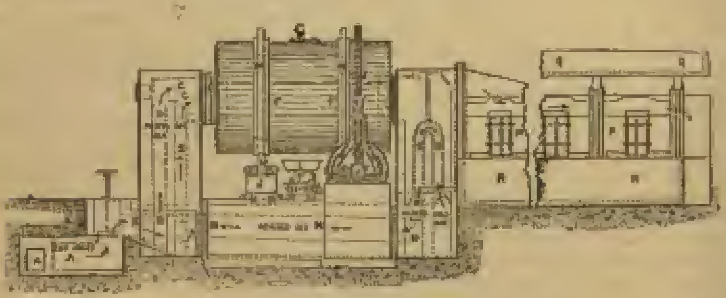


A A. Gas fire.
B B. Gas inlet for regulating supply of gas. } SIEMENS' patent arrangement.
C C. Combustion chamber. }
D D. Air inlet.
E. Ring for allowance of expansion in cylinder.
F F. Revolving furnace, lined inside with fire-bricks and blocks.
G. Charging hole when on top, and discharging hole when on bottom.
H H. Friction rings which work upon friction rollers, I I.
I I. Steel-tired friction rollers.
J J. Foundation bearers sitting upon strong iron tie-plates, K K.
K K. Foundation plates.
L. Waggon for receiving black ash, and driven by engine, M M.
M M. High-pressure engine for driving the black-ash cylinder and waggons, and being varied in speed by the gearing.
N N. Air-flue for supplying heated air to combustion chamber and heated by the waste heat after passing through the furnace, F F.
O O. Cast-iron air heater.
P P. Salting-down pan, over which the waste heat passes from the revolving furnace
Q Q. Vat for supplying salting-down pan.
R R. Drainer pan.

This furnace is provided with two beds, one of which is at a lower level than the other, the one nearest the fire being the lowest one, while the charge is introduced on the furthest one from the fire through an iron door. Two charges, each of about 7 cwt., are in work at a time, one heating, and one fluxing on the hottest bed. Towards the end of the operation much gas (chiefly carbonic oxide) is evolved, in the form of *candles*, which burn with a yellowish-green flame. At this stage tranquil fusion sets in, and the operation is completed. It is therefore raked out, after a little brisk working, into *bogies*, which are square iron boxes about 9 inches deep, set on wheels. When cold the product is known as 'ball-soda,' and each ball weighs about 5 cwt.; twelve to sixteen being produced in twelve hours.

These balls consist of carbonate and caustic soda, sulphide and carbonate of calcium, and unburned coal, &c. They contain from 22 to 26 per cent. alkali, reckoned as Na^2O; from 0·5 to 1·0 per cent. Na^2SO^4, and 0·5 to 1·0 per cent. Na^2S when properly made. By 'green balls' is meant under-roasted balls containing an excess of undecomposed sulphate, and 'burnt-balls,' signifies over-roasted balls, which are generally pregnant with sulphides of sodium, &c. Analyses of black ash necessarily differ widely, as it is not a pure chemical, and moreover, the analyses of the different samples of the same ball often differ greatly.

The chemical reactions that occur in the furnace have been made the subject of

much discussion and experiment. Mr. GOSSAGE's views are expressed in the following equation:—

$$2Na^2SO^4 + 3\ CaCO^3 + 9C = 2\ Na^2CO^3 + 2CaS + CaO + 10CO \text{ evolved.}$$

Several descriptions of furnace have been from time to time introduced, but the furnace of which an illustration is above given, introduced by Messrs. ROBERT DAGLISH and Co., is found to be the most advantageous.

This furnace is worked with SIEMENS' patent gas arrangement (see this described in Vol. ii. p. 596, GAS FURNACE), and, on consulting the references attached to the figure, the method of heating and working will be evident to the reader. This furnace itself is cylindrical, and is lined with fire-bricks, ridges of which project above the other, and act as stirrers and mixers. The flame passes in and around the inside of the furnace, and thence over the liquors contained in adjacent pans, requiring concentration.

The charge usually employed consists of 30 cwt. salt cake, 32 of limestone, and 20 or 21 cwt. of slack. These are introduced through a hopper, which serves also the purpose of a discharging mouth. Such a charge takes about 2 hours to work off, and yields 10 balls of 3 cwt. each.

The rate at which the furnace revolves at first is very slow—about 1 revolution per 20 minutes; but this can be increased at will by increasing the speed of the engine to 5 or 6 revolutions per minute, which represents the maximum speed. These furnaces are about 10 ft. in diameter by 15 ft. long, but some are now made 12 ft. in diameter and 18 ft. long. A furnace 10 ft. by 15 ft. is capable of converting about 170 tons of sulphate of sodium in 6 days.

The advantages gained by the use of revolving furnaces are: (1) Uniform heating of the charge, and a prevention of loss of sodium by volatilisation. (2) Less labour is required, and more work done in a given time. (3) The use of tools is rendered unnecessary, and the danger of absorption of soda into the beds of the furnace is obviated. The use of these revolving furnaces, however, produces 'balls,' which are dense and difficult to thoroughly lixiviate.

This has led to the carbonate of lime and part of the coal being first charged and heated for some time, so as to produce a quantity of caustic lime, the other materials being added subsequently. In this method the results obtained are better. In making 'ball soda' in revolving furnaces, patented improvements, which are in work most successfully both at St. Rollox, Glasgow, and in the Lancashire district, have been introduced.

BLYTHE and KOPP patented and worked a balling process, in which peroxide of iron was used instead of lime or chalk. The sulphide of iron so obtained was burned to furnish fresh sulphurous acid for the chambers, whilst the residual ferric oxide was used over and over again.

The losses of soda that are experienced in the 'balling operation,' as conducted in hand-worked furnaces are estimated by Dr. C. R. A. WRIGHT as follows:—

Undecomposed sodic sulphate	3·49 per cent.
Insoluble sodic compounds	5·44 ,,
Vaporisation of sodic compounds	1·14 ,,
	10·07 ,,

M. A. SCHEURER-KESTNER claims to have proved that in the furnacing operation, no soda-salts are reduced to metallic sodium, and therefore no loss by volatilisation of the metal occurs; and, moreover, that the greater part of the loss is due to the formation of insoluble sodic-salts, which are retained in the waste, a loss which is never less than 5 per cent., and often greater. He endeavours to show, moreover, that this loss increases proportionately with excess of limestone or chalk employed, inasmuch as this excess of lime becomes hydrated in the vats, and reacting upon the Na^2CO^3 forms insoluble salts.

The lixiviation of the black ash described in the First Volume, is that of CLEMENT DESORMES, which has been somewhat improved. The action of the water on the balls is thus described by KOLB in WATTS's *Dictionary of Chemistry*, vol. v. p. 327:—

(1) A given quantity of crude soda yields very different proportions of caustic soda and sulphide of sodium, according to the quantity and temperature of the water and the *time* allowed for digestion. (2) The degree of causticity of the resulting solution is not sensibly affected by the quantity of water, but increases with time of digestion and temperature. (3) The quantity of sulphide of sodium increases with the quantity of water, and more particularly with time and temperature. (4) The decrease in the amount of sodic carbonate not only corresponds to the amount of caustic soda formed, but it is also affected by the variation in the amount of sodic

sulphide formed. Hence, it would appear that the sodic sulphide is formed at the expense of the carbonate. (5) The amounts of sulphide and caustic soda formed, bear no definite relation one to the other. (6) The presence of lime or caustic soda prevents the action of sodic carbonate upon calcic sulphide, with the production of calcic carbonate and sodic sulphide.

Production of Soda-ash.—Where an inferior soda-ash is wanted, the vat liquors are boiled down, and the residue calcined in furnaces about 18 ft. long and 9 ft. wide, and lined internally with fire-bricks. The waste heat from the 'balling furnaces' is generally employed in evaporation, and in some works the flame is made to pass into a flue running along the top of the furnaces themselves, and thence downwards into main flue; whilst on the top of the furnaces are placed pans, the flue being constructed as a passage left between the furnace and the pan. Mr. GOSSAGE, among his improvements, aids the evaporation by drawing hot air through the liquors. The product is soda-ash, containing from 65 to 73 per cent. carbonate, and from 13 to 24 per cent. caustic soda, 4 to 7 per cent. sulphate of soda, and 2 to 6 per cent. of salt, besides small amounts of other substances.

If required in a purer state, as for the manufacture of plate glass, the soda-ash is mixed with about its own bulk of sawdust, and heated in a 'calker furnace,' where it is repeatedly worked by paddles at a temperature of about 600° to 700° Fahr. The sulphur and carbon are burnt off, and the caustic soda becomes carbonised. The process is known as 'calking,' and lasts from 2 to 2½ hours.

For obtaining what is known as white alkali, the soda-ash salts are re-dissolved by water in vats, aided by steam. A ton of water dissolves a ton of the ash, giving a liquor of 54° T., which is allowed to settle, and is then evaporated in iron pans, fired with coke. These pans are 20 to 30 ft. long, 7 wide, and 2 deep. The salt removed is called 'white alkali,' and contains 77 to 84 per cent. Na^2CO^3, and from traces to 5 per cent. caustic hydrate; 2 to 10 per cent. of Na^2SO^4, and 3 to 7 per cent. NaCl. SHANKS treated the black ash with carbonic acid, while WILSON patented the use of soda bicarbonate, which he mixed with the liquors in the ordinary reverberatory furnaces, stirring till dry.

To obviate the presence of sulphide of soda and sulphide of iron in black-ash liquors, GOSSAGE oxidised the Na^2S by atmospheric oxidation in towers filled with coke. With such purified liquors the excess of caustic soda must be carbonised by carbonic acid before boiling down the liquor drawn off the precipitated sulphide of iron, ensuing on the oxidation of the Na^2S to Na^2SO^4.

Mr. G. E. DAVIS, in a paper on the manufacture of white caustic soda, read before the Society for the Promotion of Scientific Industry, May 25, 1875, gave the following analyses of this salt :—

	A	B	C
Carbonate of sodium	28·144	81·807	28·330
Oxide "	5·860	5·614	3·844
Chloride "	2·808	2·574	5·101
Sulphate "	0·192	0·191	3·037
Sulphite "	0·151	0·072	none
Hyposulphite "	0·189	0·853	0·126
Sulphide "	0·358	0·163	6·645
Aluminate "	0·344	0·752	0·923
Silicate "	1·026	0·914	0·758
Cyanide "	0·186	0·043	0·422
Sulphocyanide "	0·074	0·021	0·077

In the working of the improvements described a mixture of sulphate of soda with coal and with a quantity of carbonate of lime, barely in excess of the chemical equivalent, is charged at one time into the revolving furnace, and the heating operation is allowed to proceed until the reaction is nearly complete, which is recognisable by the fluxing in the materials and other signs. At this point a small quantity, say 10 per cent., of crushed caustic lime is added; and then, as soon as this added caustic lime is thoroughly mixed with the other materials, the entire charge is withdrawn. The quantity of caustic lime to be thus added will vary accordingly as the manufacturer wishes to have more or less of the soda in a caustic state, 3 to 4 per cent. having in practice given good results in cases in which a minimum proportion of caustic soda was desired.

Among the advantages attending these improvements, the following may be enumerated :—(1) The proportion of carbonate of lime being diminished, a much increased quantity of sulphate of soda may be decomposed in a furnace of a given size. (2) The time occupied in finishing each charge being reduced, an increased number of charges can in most cases be worked in a given time. (3) There is a great saving of

coal and carbonate of lime. (4) A diminished proportion of waste is left on lixiviating, and consequently less soda is lost with the waste. (5) A diminished proportion of caustic soda and sulphides is found in the liquors, the total caustic lime being alterable at pleasure.

The Ammonia Process.—The only remaining plan of making soda, which requires notice, is technically known as the 'ammonia process'; and it is the only one which, as a rival to LEBLANC'S, has met with any measure of success. The following list of patents having reference to it shows how great is the interest taken in it:—DYER and HEMMING (its inventors), in 1838; SCHLOESING, in 1854; GOSSAGE, in 1854; BELFORD, in 1855; SCHLOESING and ROLLAND, in 1858; SOLVAY, in 1863 and 1867; YOUNG, in 1871 and 1872; SOLVAY, in 1872; WELDON, in 1872 and 1873.

The process itself consists in treating a solution of salt with bicarbonate of ammonium, practically with carbonic acid gas and ammonia at the same time. Bicarbonate of sodium is thus produced, and a solution of chloride of ammonia results, from which the ammonia is regenerated. The process may be said to depend upon the relative solubility of chloride of ammonium and bicarbonate of soda, and therefore it is necessary to work with very strong solutions. GOSSAGE prepared his bicarbonate of ammonium by exposing currents of carbonic acid and ammoniacal gas to a shower of water in a tower, and decomposed common salt, either with the dry product, or direct by ammonia and carbonic acid. From the bicarbonate of soda so produced the second molecule of carbonic acid was recovered by heating the substance in iron retorts. But he found the great difficulty of the process existed in the loss of ammonia. The following reaction cannot be realised in practice:—

$$NaCl + NH^3 + CO^2 + H^2O = NaHCO^3 + NH^4Cl;$$

for with equivalent quantities of ammonia and salt, even when excess of carbonic acid is used, only two-thirds of the soda are obtained as bicarbonate, and thus a large amount of bicarbonate of ammonium is wasted. If 2 equivalents of salt be taken to 1 of ammonia, four-fifths of the ammonia are utilised, but much salt remains undecomposed. Moreover, carbonic acid must be employed in a pure state and under considerable pressure in order to insure perfect absorption.

Mr. WALTER WELDON has forcibly drawn attention to the serious difficulty which accompanies the alkali trade. At a meeting of the British Association he alluded to the production of alkali waste in the following words:—

'The most important industrial chemical process ever yet invented—that by which soda is ordinarily manufactured from common salt—had, he said, one serious drawback. For every ton of soda ash which it produces it produces also from $1\frac{1}{2}$ to 2 tons of residual product, which is known as "alkali waste"; which product accordingly accumulates in enormous quantities in the neighbourhood of all alkali works which are not so situated as to be able to throw it into the sea, consequently it sends off offensive exhalations and liquids. As this is due to the sulphur in it, many attempts had been made to treat the waste for the recovery of the sulphur. Mr. WELDON then alluded to the various processes which had been employed for treating, not the waste itself, but the yellow liquor which drains naturally from heaps of waste exposed to atmospheric influences. Mr. M'TEAR, of Messrs. CHARLES TENNANT and Co., of Glasgow, devised a remarkably simple process, which is as effective as it is simple, and which, in Mr. WELDON'S opinion, ought always to be employed whenever the yellow liquid can be intercepted on its way to the water courses. Dealing, however, only with the drainage from the waste heaps, Mr. M'TEAR'S process, even if it could be universally applied, would only partially avoid the inconvenience resulting from the production of alkali waste; and it was not conceivable that these inconveniences could ever be fully remedied by any process commencing after the waste had been produced. In order to the practical realisation of the process, one must be able to employ, for the reaction of carbonaceous matter upon sulphate of soda, a vessel or furnace unattackable by sulphide of soda; and one must also be able to secure that neither air nor the products of combustion should have access to the interior of that vessel while the reaction is going on. The first-mentioned object can be perfectly accomplished by lining the vessels or furnaces with carbon. Mr. HENDERSON of Glasgow has used carbon bricks for the beds of furnaces, producing them by mixing powdered coke with a small quantity of tar, filling this mixture into iron moulds, and then subjecting the moulds and their contents to a red heat. For the purpose under consideration bricks of agglomerated coke, made after Mr. HENDERSON'S manner, leave nothing to be desired. The second object can be accomplished by heating the sulphate of soda and the carbonaceous mass. Mr. WELDON then described the apparatus by which he proposed to carry out this method of making sulphide of sodium on a larger scale than that of his experiments hitherto. It consists essentially of 2 furnaces—a SIEMENS' furnace for heating sulphate of soda at least to

fusion, and a revolving furnace lined with carbon, in which first to heat powdered coke to incandescence, and then to effect its reaction upon the fused sulphate of soda.' In summing up, he said he had 'described in outline a process for converting salt-cake into soda ash and free sulphur, without production of any residual product, offensive or otherwise, which he had satisfied himself is capable of industrial application, and which he expected to have at work on an appreciable scale within a few months.'

He added that he had full confidence that the method he had described of producing sulphide of sodium would effect the suppression, not only of the nuisance and the loss of the valuable material which result from the production of alkali waste, but also of the partly similar nuisance and similar loss which occur so largely in the manufacture of glass.

Caustic Soda.—Up to 1860 most of the caustic soda produced was of the character known as 'cream soda,' that is soda which has been concentrated in the state of liquor until on cooling it has set in a hard state. But in November 1860 RALSTON patented the following improvements:—'If it is desired to produce a hydrate of great strength, evaporating and separating the foreign salts, but in place of keeping the heat low as hitherto, the evaporation is continued, and the heat raised until the iron separates as oxide of iron, and until the oxide is precipitated to the bottom of the vessel, the clear alkali is then separated from the iron.' DEACON, however, had pointed out that his firm made their first batch of caustic soda in this way in 1857. It is further known that GAMBLE and SON of St. Helen's had even been before DEACON, while Mr. MCBRYDE also made caustic soda in 1859.

For causticising, the process is as follows:—A weak solution of carbonate of soda is made, and the liquors are run into the 'causticiser,' or 'operation pan,' an apparatus of varying size. The operation pan is 25 × 6 × 6 ft., and is provided with a circular bottom so as to facilitate agitation, and an agitator worked by a bracket engine. In addition to these, there are steam pipes for heating the charge to 100° C., a valve for running off the mud, and a drop syphon for decanting the clear liquor which is eventually obtained.

In some works no agitator is employed, but a current of air which is blown in along with the steam acting effectually as an agitating cause, and serving the useful purpose of oxidising any sulphides that may be present. In some works litharge (oxide of lead) is added to remove the sulphides, but the advisability of its use is questionable.

The liquor contained in the causticiser is heated to boiling by means of steam, and supplied with sufficient freshly-burnt lime as free as possible from alumina and silica. This is generally supplied through an iron cage, which retains stones and big lumps; meanwhile the agitation and steaming are continued, and carried on until a little of the filtered solution gives no effervescence on the addition of dilute acid. The principal reaction that occurs in the causticiser consists in the removal of the carbonic acid from the soda, thus:—$Na^2CO^3 + CaO = Na^2O + CaCO^3$. The use of bad lime often produces a liquor which will not settle well; and thus traces of lime are left in the resulting caustic soda, and produce trouble. Eleven to 16 cwt. of well burnt lime are required per ton of 60 per cent. caustic soda, and 1 to 1½ hour is consumed in the causticising operation. After settling, the liquors are run off, and the operation pan is charged afresh, without removing the sludge until the second operation is completed. The lime mud remaining after this is washed by agitation with water, first in the pan, and then finally on a 'filter.'

This filter is generally half a boiler cut longitudinally in twain, but when specially made it is about 20 ft. by 10 ft. by 4 ft. deep. The bottom is lined with bricks set on edge, about 2 in. apart, a channel being preserved along the central axis. The bricks are covered loosely with 8 or 9 in. thickness of coke or limestone, and over this comes a layer of coarse sand or cinders. Finally, over the whole are spread iron grids, so as to present flat surfaces, from which the lime mud, when well washed and drained, can be readily removed. Sometimes this filtration is aided by the use of a vacuum pump, and in any case it should be continued until the mud contains about 50 per cent. water, and gives up to water about 1 per cent. caustic soda.

More than 20,000 tons of caustic soda is made annually in England, of the value of 350,000*l*., and therefore any question regarding an improvement in such a trade deserves the most careful study.

We have to acknowledge our obligations to an extended series of papers on the 'History, Products, and Processes of the Alkali Trade,' by CHARLES T. KINGZETT, which have been appearing in *Iron* during 1876, for some of the facts named.

Mr. JAMES MACTEAR read before the Chemical Section of the British Association at Glasgow, 1876, a paper on this subject, from which we extract the following on the manufacture of salt in relation to the rise of the alkali trade. In 1798 (previous to the rise of duty, which came into effect in the summer of that year), the quantity of

salt manufactured in Scotland was 350,000 bushels of 56 lb. each, or 8,750 tons produced from 118 pans. These were estimated as follow:—

Near Aberdeen	5 pans
" Ayr	1 "
" Alloa	6 "
" Anstruther	7 "
" Borrowstounness	27 "
" Irvine	4 "
" Kirkcaldy	27 "
" Montrose	3 "
" Prestonpans	37 "
" Stranraer	1 "
Total	118 pans

Producing annually 350,000 bushels at 56 lb. each = 8,750 lb.

These pans yielded five castings of salt per week, weighing 10 to 11 cwt. each, according to the strength of the sea water.

In order to produce this salt, the pan was filled three times till within four inches of the brim (they cannot be filled more with advantage to the ebullition). The first two fills are boiled down till the salt begins to form—the first down to within 1 in. of the bottom, the second to about 1½ in., and the last to about 2½ in., which consists chiefly of pretty dry salt. This salt is then raked to the side of the pan, and thrown into a square chest, where it is allowed to drain till a third casting is ready to replace it, two chests being always employed.

While in this situation it yields about 20 gallons of bittern, or 'pan oil' as the workmen call it.

For each pan there are four small round vessels of 8 in. by 4 in., placed one in each corner, which during the evaporation, collect all the insoluble salts, and impurities deposited during the process, sometimes more or less, in proportion, it is said, to the weakness of the water.

State of charges by the ton weight.

	£	s.	d.
Wages	1	1	8
Coal dross, about 180 cwt., at 1*d.*	0	15	0
Tear and wear, say	0	10	0
Rent, say	0	4	0
Cartage of coals, at ¼ cent. per cwt.	0	3	0
	2	14	5

The manufacture of salt is still continued at Saltcoats, but on a different system, the sea water being employed to dissolve rock salt obtained from Ireland, which gives a solution requiring much less evaporation than the old system.

This method is also carried out to a small extent in Glasgow.

The following table gives the prices of salt for chemical purposes in Glasgow from the year 1798:—

Year	Price per ton
1798	£12 to £18
1800	12 0 0
1801	No details
1802	"
1803	12 0 0
1804	12 0 0
1809	19 0 0
1814	11 0 0
1819	1 12 0
1824	2 6 0
1829	1 2 0
1834	0 19 0
1839	1 1 0
1844	0 16 0
1849	0 17 0
1854	0 15 0
1859	0 16 0
1863	0 14 0
1869	0 14 6

At or about which price it has since remained.

The quality of salt used for chemical purposes previous to the introduction of the method of bleaching by chlorine, must of course have been small. Marine acid, however, was made, and there is a tradition amongst the oldest workmen of the chemical works that it was produced (some years previous to the introduction of sulphuric acid, about 1749) by the distillation of salt and earthy matter. That this process was actually in use is extremely probable, as it is described by the writers of the last century, eight parts of clay or bolar earth to one of salt, being the mixture recommended, distilled in stoneware retorts.—*Chemical News*, January 5, 1877.

For additional particulars relative to the Alkalies and to Chlorine, and for improvements on DEACON's process, see *Fabrication du Chlore d'après le procédé de Deacon*, by R. HASENCLEVER, *Berichte d. deuts. chem. Gesellschaft zu Berlin*, ix. p. 1070, and *Archives des Sciences Physiques et Naturelles*, October 1876.

Imports of Alkali in 1875 and 1876.

	cwt.	Value
From Germany	958	£1,360
" Holland	975	775
" Belgium	2,491	3,158
" Canary Islands	3,921	1,000
" United States of America	6,605	10,446
" British North America	76,009	119,611
" Other countries	433	455
	91,392	£136,835
Total imports, 1876	92,706	£118,163

Exports of Alkali in 1875 and 1876, Manufacture of United Kingdom.

	cwt.	Value
To Russia	354,270	£197,532
" Sweden and Norway	136,640	52,313
" Denmark	105,445	32,437
" Germany	832,945	320,329
" Holland	385,476	136,618
" Belgium	285,483	142,589
" France	147,977	65,856
" Spain and Canaries	131,958	85,736
" Italy	106,281	47,568
" Austrian Territories	50,363	21,075
" United States (*Atlantic*)	1,988,365	954,795
" " (*Pacific*)	49,205	26,892
" Brazil	37,988	21,505
" Australia	106,940	48,660
" British North America	86,157	43,746
" Other Countries	217,268	101,859
	5,022,764	£2,299,937
Total exports, 1876	5,417,120	£2,209,284

ALKALI FROM SEA-WEED. Mr. THOWOLD SCHMIDT of the chemical works at Aalborg in Jutland, Denmark, obtains from sea-weed iodine, potash salts, and other products. After sea-weed is dried and burnt, a concentrated solution of the ash is made and added to the water containing the chlorides of sodium and calcium, left after the ammonia has been recovered by boiling with lime. The sulphate of potash, soda, and magnesia, contained in the ash of the sea-weed, are decomposed, and hydrated sulphate of lime and hydrated magnesia are precipitated in a form which may be available for paper-making. The last traces of sulphates are got rid of by adding a small quantity of solution of chloride of barium. Into the clear solution nitrate of lead is now added, until all the iodide is precipitated as iodide of lead, which is then separated by filtration, and treated for the production of iodine or the iodides. The liquor is filtered and treated with nitrate of soda, to convert the chloride of potassium into nitrate of potash. There remains a solution of common salt containing traces of ammonia, and a trace of chloride of potassium. The solution

is again treated by the ordinary ammonia soda process for the production of bicarbonate of soda and white alkali.

The following list exhibits the different kind of potashes of best quality which come into the market:—

	Quality	Carbonate of potash with hyd.-carb. and carbonate	Carbonate of soda	Sulphate of potash	Chloride of potassium
American . .	1	104·4	1·4	4·0	2·0
"	2	71·2	8·2	16·1	3·6
" pearlash . . .	...	71·3	2·3	14·3	3·6
Tuscan potash . . .	...	74·1	3·0	13·4	0·9
Illyrian " . . .	...	89·3	...	1·2	9·5
Russian " . . .	...	69·6	3·0	14·1	2·0
Siebenbürger potash . .	...	81·2	6·8	6·4	0·6
Hungarian house ashes . .	...	44·6	18·1	30·0	7·3
Salician potash . . .	...	46·9	3·6	29·9	11·1
Refined sheep-wash . .	...	72·5	4·1	5·9	6·3
French beetroot ash . .	1	90·3	2·5	2·8	3·4
" " . .	2	80·1	12·6	2·5	3·4
German potash . . .	1	92·2	2·4	1·4	2·0
"	2	84·0	8·2	2·8	3·5

H. Grüneberg, *Dingl. polyt. J.*, ccxiv.

ALLOYS. (Vol. I. p. 90.) (*Alliage*, Fr.; *Die Legirung*, Ger.) *Platinum and Iron*.—M. Henry Sainte-Claire Deville states that platinum and iron readily alloy. In analysing the native platin-iridium this alloy is readily formed, the oxides being intimately mixed. This alloy, if digested with hydrochloric acid, allows but a slight escape of hydrogen; and very little iron is dissolved, even when it exists in the alloy to the extent of 10 per cent. Iron and iridium, says M. Deville, are capable of combining at low temperatures, and the same is probably the case with iron and platinum. Breithaupt admits the existence of platinum ores containing 14 to 19 per cent. of iron. Berzelius only once found a specimen containing as much as 12·98 per cent., and MM. Debray and Ste. Claire-Deville have never found more than 12 per cent. Platinum may be freed from iron by cupellation in chlorine gas. If heated from 1200° C. to 1500° C. in this gas, it is volatilised in the form of brilliant crystals, and deposited in the hot parts of the apparatus.—*Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, March 8, 1875.

Platinum and Iridium.—Mr. G. Matthey, of the firm of Johnson and Matthey, presented to the Academy of Sciences a measure of 4 mètres, executed in an alloy of platinum and iridium.

The specific gravity of the alloy was 21·508, and its composition was found to be—

Platinum	89·40	89·42
Iridium	10·16	10·22
Rhodium	0·18	0·16
Ruthenium	0·10	0·10
Iron	0·06	0·06
	99·90	99·96

Comptes Rendus, December 4, 1876.

Chromium. A name given to an alloy of iron and chromium, which is of such intense hardness that it will cut hard steel.

Iron, Tin, and Lead.—A very liquid alloy is obtained by mixing—

Cast iron	79·00 per cent
Tin	19·50 "
Lead	1·50 "
	100·00

This alloy is slightly malleable, and could be used for casting small articles.

Sergius Kern, *Chemical News*.

Japanese Alloys.—Four Japanese metallic alloys were examined by M. A. Kalischer, and the composition shown to be.—

	I.	II.	III.	IV.
	per cent.	per cent.	per cent.	per cent.
Gold . .	4·16	0·12	...	...
Silver . .	0·08	48·03	...	...
Copper . .	95·77	51·10	76·60	76·53
Tin . .	...	...	4·38	4·36
Lead . .	...	...	11·88	12·29
Zinc . .	...	...	0·53	6·58
Iron . .	...	...	0·47	0·33
Total .	100·01	100·15	99·86	100·09

Nos. 3 and 4 resemble brass in colour.—*Dingl. polyt. J.*, ccxx.

ALLYLENE. A diatomic radicle, which bears to allyl the same relation which ethylene, C^4H^4, bears to ethyl, C^4H^5. See COAL GAS.—WATTS's *Dictionary of Chemistry*.

ALMAGERITE. An anhydrous sulphate of zinc, which is isomorphous with *Anglesite* and heavy spar, found at the Barranca Jaroso Mine, in the Sierra Almagrera, Spain.

ALMANDINE RUBY. The name given to the violet coloured varieties of spinel.

ALMANDINE SPAR. *The eudialite.* A mineral composed of silica, zirconia, iron, and soda, found on the west coast of Greenland.

ALOE FIBRE. Obtained from the leaves of the larger Agaves, such as *A. Americana* and *A. Mexicana*. See PITA, TEXTILE MATERIALS.

ALOETIN, or **ALOES RESIN.** (ALOE, Vol. I. p. 101.) WINKLER considers this substance to be an acid, but BERT thinks it a mixture of two acids. According to M. ULEX, commercial aloes consists of—

Aloin	69·2 parts
Aloetin	25·6 ,,
Albumen	5·2 ,,

This substance when treated with nitric acid is converted into a beautiful golden yellow substance, *chrysammic acid*; but it has never been much used in this country as a dye, although employed in Germany and France.

Several attempts have been made to use aloes as a colouring matter, and many of the colours produced have had the high recommendation of great permanency and much intensity of colour; yet the colouring matters obtained from the aloe have never attracted the favourable attention of our dyers.

ALLOXAN. When uric acid is acted upon by nitric acid, it is converted into urea, a neutral substance, and alloxan:—

$$\underbrace{(C^{10}H^4N^4O^6)}_{\text{Uric acid}} + (NO^5HO) = \underbrace{C^2H^4N^2O^2}_{\text{Urea.}} + \underbrace{C^8H^4N^2O^{10}}_{\text{Alloxan.}} + NO^3.$$

Alloxan is a substance capable of crystallisation, soluble in water, of an unpleasant odour, and staining the skin red. 'Alloxan is one of those substances the molecules of which are *en mouvement perpétuel*, and hence prone to conversion into another substance called ALLOXANTIN, containing one atom less oxygen.'—CROOKES.

ALLOXANTIN. The conversion of alloxan into alloxantin is effected by the reaction of reducing agents, such as nascent hydrogen; but simple boiling in water will effect the change. Alloxantin, associated by some alloxan, is directly formed when uric acid is treated with dilute nitric acid; from alloxantin, when treated with chloride of ammonium, is formed *dialuramide*, and from that substance *murexide* or the purpurate of ammonium is generated under the following circumstances:—(*a.*) By the oxidation of dialuramide by means of the oxides of silver or mercury. (*b.*) By the action of ammonia upon alloxantin. (*c.*) By the action of ammonia or of carbonate of ammonia upon *alloxan*; or better, a mixture of alloxan and alloxantin. (*d.*) By destructive distillation of alloxan by itself, or of that substance mixed with an organic body. See MUREXIDE.

ALTAITE. An ore of tellurium, found at the Red Cloud Mine, and at Kizi Mountain, in Gaston Co., N.C.

At Red Cloud the altaite is found in large quantities with native tellurium, sylvanite, pyrites, siderite, and quartz. It is sometimes found in small imperfect cubes, usually coated with galena; more rarely in large cleavable masses, most frequently in coarse grains.

It contains—

[illegible]	Au	Ag	Cu	Pb	Zn	Fe	Te
0·19	0·19	0·62	0·06	60·22	0·15	0·48	37·99 = 99·90
0·32	0·16	0·79	0·06	60·53	0·04	0·33	37·51 = 99·74

See TETRADYMITE, PETZITE, SYLVANITE. F. A. GENTH, *Jour. für prak. Chem.*

ALTHÆA ROSEA, HOLLYHOCK. Used in adulterating wines. See WINES.

ALUM. (Vol. I. p. 105.) *The manufacture of Alum under pressure.*—M. FAVDEL recommends for the use of the paper-maker, alum cake prepared by heating china clay with sulphuric acid under a pressure of 2 to 2½ atmospheres in leaden vessels.

1·5 part of clay, heated to 135°–140°, under a pressure of 3 to 3½ atmospheres, with 1·8 part of sulphuric acid of 1·525 sp. gr., yielded a cake which dissolved almost entirely in water. Its composition was—

Water and impurities	37·5
Sulphate of alumina	37·0
Silicic acid	19·5
Free sulphuric acid	6·0

The free acid may be neutralised by the addition of alumina.—*Dingl. polyt. J.*, ccxix.

ALUMINA AS A MORDANT. In the *Derniers Progrès de l'Industrie Chimiques*, published under the superintendence of Professor A. W. HOFMANN, there is much information on the use of alumina as a mordant which must have especial interest. From this we extract the more important points:—

'In printing and dyeing preference is given to a neutral alum, which is made by boiling together 12 parts of ordinary alum and 1 part of lime. The use of this neutral alum is to prevent the alteration of colours by an acid reaction.

'The active principle of alum resides in the sulphate of alumina, for the sulphate of potash or of soda can be replaced by sulphate of ammonia without the least change in the action of the alum. It would therefore appear rational to employ simple sulphate of alumina. This salt is a commercial article known as concentrated alum [in England called 'patent alum,' ED.]; it forms a white slightly translucent mass, which can be cut with a knife. But the extension of its application has met with difficulties; it is too easily soluble in water (1 part dissolves in 12 parts of cold water), it crystallises with difficulty, which prevents it being obtained free from iron. For this reason it was necessary in all those cases where iron is injurious, to combine the sulphate of alumina with sulphate of potash, although the latter salt is both costly and inactive, to render the crystallisation easy, and its purification more complete.

'The most important application of alum is in dyeing and printing, where it serves as a mordant, an application depending upon the double affinity which alumina possesses for textile fibres and colouring matters. M. BIRDERMANN.

'The action of alum upon woollen fibre has been studied by M. PAUL HAVREZ, who has published his researches.

'He has found that relatively small proportions of alum act by depositing hydrate of alumina in the interior of the wool, but if the alum be employed in large quantities, the deposited alumina is redissolved, so that wool treated with a large quantity of alum does not dye up colours so dark and bright as when the alum is employed in small proportions; and further, that it acts best when the solution is hot, and the contact with the wool prolonged for a considerable time.

'M. HAVREZ believes that this is explained by the presence of lime in ordinary water. As it might be supposed that the difference of the action of alum, according as it was employed in large or small quantities, was produced by a small quantity of alkali which the wool had retained from the scouring processes, or that ammonia might exist in the wool itself, he washed some wool with water slightly acidified with nitric acid, but this did not interfere with the decomposition of the alum and the deposition of alumina in the interior of the fibre. It is therefore concluded that the wool itself is the active agent.

'M. REIMANN believes that there is dissociation of the elements of the alum, basic sulphate of alumina being separated, while the sulphuric acid, also separated, is diluted with so great a quantity of water as to be unable to exercise any solvent action upon the basic salt deposited upon the fibre. This salt by long contact with water parts with a further portion of its sulphuric acid, leaving a hydrate of alumina containing only a very small portion of acid. But if there is much alum in solution, there is difficulty in the formation of the basic salt, which would be re-dissolved continually by the acidity of the bath.

'However this may be, the practical operations are agreeable to the experiments of M. HAVREZ. All wool dyers know that mordanting with alum is only good to a certain extent. In general, the practice is, in aluming, to take 1 part of alum for 10

parts of wool. To alum 30 lb. of wool, it is necessary to use 3 lb. of alum, and 1500 lb., or 150 gallons of water, or, so that the solution contains 2·10 per cent. of alum.

'If sulphate of alumina be used instead of alum, it ought to be not only free from iron, which is the case in good qualities of this salt, but also from an excess of sulphuric acid. To discover free acid ordinary reagents are useless, because sulphate of alumina itself has an acid reaction. M. GIESSE recommends the two following methods: Triturate 5 grammes of the solid sulphate of alumina with 50 cubic centimètres of absolute alcohol; throw the mixture on a filter, and wash with absolute alcohol to the bulk of 100 c.c. Sulphate of alumina is insoluble in absolute alcohol, but the sulphuric acid dissolves in it and is all found in the filtrate, where the quantity can be determined by means of a standard solution of soda. But this method is not perfectly accurate, as neutral sulphate of alumina is not altogether insoluble in absolute alcohol. The following process is better:—

'If to a very dilute solution of sulphate of alumina or of alum, a few drops of tincture of logwood be added, they will produce a characteristic dark reddish purple when the salt is neutral, and if the salt is acid, only a weak yellowish brown colour. By this method the presence of 0·2 of free acid in 100 parts can be detected with certainty. To be able to recognise the shade with exactness, it should be compared with a standard liquor, which contains in each 100 centimètres 10 c.c. of potash alum, free from acid, and 0·5 c.c. of a tincture of logwood, made by boiling 1 part of wood with 1 part of water, and adding $\frac{1}{8}$th part of alcohol.

'To ascertain the amount of free acid, a solution of 10 grammes of the sulphate is made into 100 c.c. volume, and 0·5 c.c. of the logwood tincture added, then standard solution of soda poured in, until the dark violet red colour is produced. M. W. STEIN uses ultramarine to show the presence of free acid in sulphate of alumina. Unsized paper, coloured lightly with ultramarine, is bleached by sulphuric acid.

'Alumina is advantageously employed in dyeing and printing, under the form of aluminate of soda. In 1819, MACQUER and HAUSMANN advised the use of aluminate of potash in dyeing. With this mordant the colours differ more or less from those produced with alum, depending upon the nature of the colouring matter. To obtain the same shades as from alum, the aluminate of soda should be transformed into an acid mordant.

'M. R. WAGNER has remarked that the best alumina mordant is obtained from ethylamine aluminate. Ethylamine easily dissolves alumina, and when the solution is exposed to the air, the ethylamine evaporates and leaves the alumina pure. It is possible that sooner or later ethylamine may be manufactured on the large scale at a sufficiently low price to be used in practice. Aluminate of soda owes its activity to its easy decomposition, which is affected even by carbonic acid; alumina separates, which forms lakes with the colouring matters.

'M. P. MOHR, who was one of the first to employ aluminate of soda in the production of lakes, mixes the colouring matter with the aluminate, and precipitates by sulphuric acid. The hue of the lakes shows a difference according as the addition of acid is regulated to leave the liquid acid, alkaline, or neutral.

'An inconvenience in the preparation of lakes is, that they do not readily subside, whether made hot or cold, or however the mixture is accomplished. The difficulty is in some measure overcome by causing the lake to be formed in 1 litre of water, supposing it takes 3 litres of water to wash it. When the lake is produced it is well agitated, and then the two litres of water are added, and again stirred up. The lake then settles, and occupies only one-third of the volume of the liquid.

'M. DULLO has communicated a process of preparing alumina in a state very suitable for the preparation of lakes. The alumina, precipitated by ammonia, is in a gelatinous form, which contracts excessively upon drying, forming fissures. The alumina, precipitated from aluminate of soda by carbonic acid, at a temperature of 122° Fahr., is in the form of a compact powder. Precipitated at higher temperatures, the powder is still more and more dense, until it becomes too much so for dyeing and printing purposes. If the precipitation is conducted at a low temperature, the alumina takes the gelatinous form, the same as when precipitated by ammonia. It is produced in the same state when alum is boiled with metallic zinc; it is then extremely pure.

'By altering the process in the following manner, the alumina is obtained in the form of a very fine powder, not at all gelatinous, depositing well in a grain of extreme tenuity: dissolve 1 lb. of alum in $\frac{1}{2}$ gallon of water, and add 75 grains of sulphate of copper and about $\frac{1}{4}$ lb. of zinc turnings, leave the mixture for three days in a warm place, renewing the water lost by evaporation. The copper is first deposited upon the zinc, the two metals thus forming a voltaic couple sufficiently strong. Hydrogen is disengaged, sulphate of zinc is formed, and the alumina gradually separates in the state of a very fine powder; the action is allowed to continue until there is no more alumina left in solution, or until ammonia ceases to give

a precipitate. If the reaction is prolonged beyond this point, oxide of iron will precipitate if present. The alumina washes easily, and does not contract upon drying.

'Acetate of alumina is a very useful composition in dyeing. Before the development of the cryolite and bauxite industries, it was prepared by decomposing sulphate with the acetates of lead, baryta, or soda; but since that time it is found more advantageous to dissolve the alumina precipitated from aluminate of soda in acetic acid. The alumina precipitated by means of hydrochloric acid dissolves more easily in acetic acid than when carbonic acid is used to precipitate it. In this last case the solubility of the alumina appears to be considerably impeded by the presence of notable quantities of carbonate of soda. According to M. R. Wagner, this inconvenience is overcome by digesting the alumina for several days, either in solution of acetate of alumina containing free acetic acid, or in a solution of chloride of aluminium.

'Mr. S. M. Lyte prepares acetate of alumina by dissolving phosphate of alumina in phosphoric acid, and precipitating by acetate of lead. The acetate of alumina remains in solution, and the phosphate of lead which precipitates is used for making phosphorus and phosphoric acid.

'M. H. C. Hahn has described a process for directly preparing a mordant of alumina free from iron by means of cryolite. One hundred parts of cryolite washed, and in small pieces, are mixed with 38 parts of milk of lime; the mixture is heated by steam in a wooden vat made without iron nails; upon boiling, the decomposition is complete. When the fluoride of calcium has deposited, the clear liquid is drawn off and diluted to 10° B. It is exactly neutralised with commercial acetic acid at 6° B. After a sufficient time two-thirds of the bulk can be drawn off clear, and furnishes pure acetate of soda. The remaining portion is mixed with one-third of the amount of acetic acid first used, and then with 40 parts of sulphuric acid at sp. gr. 1·83. A solution is by this means obtained, containing a mixture of sulphate of soda, and an aceto-sulphate of alumina, which is perfectly free from iron.'—*The Textile Colourist.*

ALUMINIUM. (Vol. i. p. 126.) *Aluminium amalgam* is formed by bringing mercury containing a small quantity of sodium in contact with aluminium; or, as recommended by Joule, by electrolysing the solution of an aluminium salt with mercury for the negative pole, or by heating the two metals together in a gas which does not act on either. An impure chloride of aluminium, containing calcium and sodium salts, known commercially as *Chlor. alum*, is used as a disinfectant.

AMALGAMATION FOR SILVERED MIRRORS.—Generally mirrors have been silvered by means of an amalgam of tin. Drayton introduced the process of coating mirrors with a layer of silver, obtained by reducing the ammoniacal solution of nitrate of silver by means of the highly oxidisable essential oils.

This process was subsequently modified by several chemists, but M. Petitjean, by substituting tartaric acid for the reducing agents usually employed, introduced a practical process. The process employed is as follows: the glass to be silvered is laid down on a cast-iron table heated to 40° C. The surface is well cleaned, and solutions of silver and tartaric acid diluted, are floated over it. The liquid, in consequence of a well-known effect of capillarity, does not flow over the edges of the glass, but it forms a layer of some thickness upon it. In twenty minutes the silver begins to be deposited on the glass, and in a little more than an hour the process is complete. The liquid is poured off, the glass washed with distilled water, dried, and covered with varnish to protect it.

Glasses thus prepared are liable to become yellowish. M. Lenoir has succeeded in overcoming this defect. The glass silvered as above directed is washed, and then sprinkled with a diluted solution of the double cyanide of mercury and potassium. The silver displaces a portion of the mercury, and enters into solution, while the rest of the silver forms an amalgam, whiter and much more adhesive to the glass than pure silver. The effect is instantaneous, the result is perfection of colour, and the firmest possible adhesion to the glass.—*Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, January 25, 1876.

AMALGAMS. Sodium amalgam containing excess of mercury, when heated to 440°, leaves the compound Na^3Hg. Potassium amalgam, under the same circumstances, leaves K^2Hg. Both are silvery crystalline substances. The latter takes fire easily, resembling in this respect potassium.

Lead, tin, zinc, cadmium, and bismuth, retain mercury at 360°, but not at 440°. By heating amalgams in vapour of sulphur (*a*), mercury (*b*), and diphenylamine (*c*), the following compounds were obtained:—

(*a*)	Au^4Hg	$Ag^{12}Hg$	$Cu^{14}Hg$	K^2Hg	Na^3Hg
(*b*)	Au^4Hg	$Ag^{12}Hg$	$Cu^{14}Hg$	Pt^2Hg	
(*c*)	Au^4Hg	$Ag^{12}Hg$	$Cu^{14}Hg$		

E. de Souza, *Deut. Chem. Ges. Ber.* ix.

AMALGAMATION, GOLD. (See Gold, Amalgamation.)

AMBER. (Vol. i. p. 135.) (*Ambre*, Fr., *Der Bernstein*, Ger.) The following (Marcinowski, *Pruss. Zeit.* xxiv. p. 138) is of interest as showing the progress of the trade in amber:—

Amber is got at numerous places along the north-eastern coast of Prussia, both by inland diggings and by divers and dredging in the sea. The production during 1874 and 1875 from the various sources—distinguishing the method of getting—was—

		1874	1875
At Brusterort (by diving)		35·35 cwt.	2·12 cwt.
„ Palmnicken „		12·10 „	152·39 „
„ do. (by digging)		847·60 „	770·0 „
„ Sassau „		229·63 „	312·76 „
„ Schwarzort (by dredging)		1013·16 „	937·72 „
		2138·49 „	2174·69 „
Shore gleanings (thrown up by the sea)	about		150 „
Total yield			2314·69 „

The value of rough amber varies very considerably, increasing with the size and colour of the pieces, rendering an elaborate classification necessary. The following are the principal sizes and prices at the present time:—

1. Angular Pieces.

A. *Fliessen (long pieces suitable for large pipe mouth-pieces).*

	per lb.
4 to 5 pieces per lb.	6*l.* to 7*l.* 10*s.*
10 „	3*l.* 12*s.*
15 „	2*l.* 2*s.*
25 „	1*l.* 10*s.*
50 „	15*s.* to 1*l.* 1*s.*
80 „	12*s.* to 15*s.*
100 „	9*s.*
150 „	3*s.*

B. *Platten (angular pieces of any other form).*

25 pieces per lb.	45*s.*
40 „	24*s.*
75 „	12*s.*

And 7 lower classes, varying from 1*s.* 6*d.* to 9*s.*

2. Round Pieces.

10 pieces per lb.	36*s.* to 38*s.*
35 „	33*s.*
50 „	21*s.*
70 „	12*s.*
100 „	7*s.*

And 3 lower qualities, below which is the so-called 'Knibbel,' worth from 1*s.* to 1*s.* 6*d.*

About 15 per cent. of the total yield is impure, and only fit for manufacturing purposes, varnish, &c.; 70 per cent. is in various larger sizes suitable for pipe mouth-pieces, large beads, and other ornaments, the remaining 15 per cent. being used for small beads.

In the larger sizes the transparent kinds are about 40 per cent. cheaper than those of a fine clouded character.

The impure qualities, as well as the waste in manufacture, are used in the production of lacquer varnish, oil of amber, succinic acid, and incense or fumigating powder.

The value of rough amber sold in the Danzic market in 1875 was:—

		£
1.	From the Danzic and Konigsberg shore	7,000
2.	„ shore diggings at Danzic	7,500
3.	„ the Pomeranian shore	600
4.	„ the Memel shore	600
5.	„ Schwarzort dredgings, Palmnicken and Sassau diggings	19,500
6.	„ diggings in the peninsula (Erlstein)	4,000
		39,200

The production has of late years been very largely increased by the adoption of dredging at Schwarzort, especially in the higher qualities; but for these the prices have not materially varied during the past ten years. The present production is about three times that of 1858. About two-thirds of this was worked up in the home manufactures, the remainder being exported in the rough.

The principal seats of the amber manufacture in Germany are in Danzic, Stolp, Königsberg, Worms, Ruhla, and Nurnberg; and in other countries, Vienna, Paris, Polangen in Russia, Constantinople, and a few towns in China. The most important production is in Vienna, which supplies nearly all the world with mouth-pieces for pipes and cigar holders.

Of large production of amber ornaments, beads, and so-called corals, in Danzic, is mainly distributed through the following places:—

1. Leghorn and Egypt, for distribution to the north and east coast of Africa.
2. London and Paris, for the west coast of Africa.
3. Constantinople, Syria, and Asia Minor, taking cloudy olive-shaped beads.
4. China, clear olive beads.

AMMONIA. (*Ammoniaque*, Fr.; *Das Ammoniak*, Ger.) M. O. WACHSMUTH publishes in the *Arch. Pharm.* vi. a paper on the strength of ammonia. A concentrated solution of ammonia being obtained, it was diluted. The specific gravity obtained at each addition, and the amount of ammonia present, determined by hydrochloric acid.

The following table gives the amount of ammonia contained in solutions of which the various specific gravities are given:—

Specific gravity at 12° C.	1 kilo. contains ammonia in grains	1 litre contains ammonia in grams	1 litre consists of	
			Water in C.C.	Liquid ammonia in C.C.
0·870	384·4	334·5	535·5	464·5
0·872	376·9	328·6	543·4	456·6
0·874	369·4	322·8	551·2	448·8
0·876	362·0	317·1	558·9	441·1
0·878	354·6	311·3	566·7	433·3
0·880	347·2	305·5	574·5	425·5
0·882	340·0	299·8	582·2	417·8
0·884	332·9	294·2	589·8	410·2
0·886	325·8	288·6	597·4	402·6
0·888	318·7	283·0	605·0	395·0
0·890	311·6	277·3	612·7	387·3
0·892	304·7	271·7	620·3	379·7
0·894	297·8	266·2	627·8	372·2
0·896	290·9	260·6	635·4	364·6
0·898	284·1	255·1	642·9	357·1
0·900	277·3	249·5	650·9	349·5
0·902	270·7	244·1	657·9	342·1
0·904	264·1	238·7	665·3	334·7
0·906	257·7	233·4	672·6	327·4
0·908	251·3	228·2	679·8	320·4
0·910	244·9	223·8	687·2	312·8
0·912	238·6	217·6	694·4	305·6
0·914	232·3	212·3	701·7	298·3
0·916	226·0	207·0	709·0	291·0
0·918	219·7	201·6	710·4	283·6
0·920	213·4	196·3	723·7	276·3
0·922	207·3	191·1	730·9	269·1
0·924	201·2	185·9	738·1	261·9
0·926	195·1	180·6	745·4	254·6
0·928	189·0	175·4	752·6	247·4
0·930	182·9	170·1	759·9	340·1
0·932	176·9	164·8	767·2	232·8
0·934	170·9	159·6	774·4	225·6
0·936	164·9	154·3	781·7	218·3
0·938	158·9	149·0	789·0	211·0
0·940	152·9	143·7	796·3	203·7
0·942	147·1	138·5	803·5	196·5
0·944	141·3	133·3	810·7	189·3

Specific gravity at 15° C.	1 kilo. contains ammonia in grams	1 litre contains ammonia in grams	1 litre consists of	
			Water in C.C.	Liquid ammonia in C.C.
0·946	135·6	128·2	817·8	182·2
0·948	129·9	123·1	824·9	175·1
0·950	124·2	118·0	832·0	168·0
0·952	118·7	113·0	839·0	161·0
0·954	113·2	108·0	846·0	154·0
0·956	107·8	103·0	853·0	147·0
0·958	102·4	98·1	859·9	140·1
0·960	97·0	93·1	866·9	133·1
0·962	91·6	88·1	873·9	126·1
0·964	86·2	83·0	881·0	119·0
0·966	80·8	78·0	888·0	112·0
0·968	75·5	73·0	895·0	105·0
0·970	70·2	68·0	902·0	98·0
0·972	65·2	63·3	908·7	91·3
0·974	60·2	58·6	915·4	84·6
0·976	55·2	53·8	922·2	77·8
0·978	50·2	49·1	928·9	71·1
0·980	45·3	44·0	935·7	64·2
0·982	40·4	39·6	942·4	57·6
0·984	35·5	34·9	949·1	50·9
0·986	30·6	30·1	955·9	44·1
0·988	25·8	25·5	962·5	37·5
0·990	21·0	20·7	969·3	30·7

M. O. Wachsmuth remarks that concentrated ammonia solution is necessary for the effective working of Carré's ice machines.

AMMONIA in anthracite and in soils, see Anthracite. Detected on the rupture of bars of steel, see Steel.

AMMONIA IMPURITY IN GAS. The gas referees made a report to the Board of Trade, which furnishes some valuable information on ammonia purification. From it we extract the following:—

The process of purifying gas from ammonia consists mainly in bringing the gas in contact with water, which has a remarkable affinity for ammonia, water being capable of absorbing fully 700 times its own volume of ammonia. And the most perfect process of ammonia purification is that which does its work with the least amount of water: (1) Because when much water is used it tends to absorb a portion of the hydrocarbons which constitute the light-giving element of gas. (2) Because the ammoniacal liquor so formed is too weak to be saleable in that condition. And (3), in consequence of this, the 'liquor' has to be returned into the scrubbers several times to bring it up to the required strength, whereby the impurities with which the water is charged are again brought in contact with the gas.

In many provincial gasworks the ammonia purification is effected by 'washers,' an apparatus in which the gas is made to pass or bubble through water; in some other gasworks the process in use may be described as a shower-bath, where the gas passes up through a descending shower of water. Both of these processes are defective in this respect, that the gas is never brought in contact with clean water, the 'liquor' being kept in the washers, and returned into the shower-bath apparatus until it is brought up to the saleable strength: an arrangement which, as already said, is objectionable, inasmuch as the water absorbs, besides ammonia, sulphuretted hydrogen and carbonic acid: and all these impurities, being volatile, are liable to be given back into the gas. It is true that the same system of returning the 'liquor' into the apparatus until it acquires a saleable strength generally prevails also where scrubbers are used; but the difference is, that with washers and in the shower-bath apparatus this system is indispensable, whereas it may be wholly avoided if a perfect kind of scrubber is used. Moreover, in almost every case where scrubbers are used the gas is brought in contact with clean water in the last scrubber of the series, thereby cleansing the gas to an extent which is impossible in washers.

A minute division also, both of the water and of the gas, is of paramount importance in ammonia purification, for the absorbent power is confined to the *surface* exposed to its action. Even in scrubbers the minute division of the water is sometimes too little attended to: the water being passed through the apparatus in excessive

quantity, in fact, in streams, with no improvement as regards ammonia purification, and with disadvantageous results to gas companies as regards economy and convenience. The more finely or minutely the water is divided in the scrubber, and the more equally distributed over the scrubbing material, the more efficient is the process of ammonia purification.

The scrubber consists of a tall iron cylinder filled with pieces of insoluble material, between which the water percolates in such a manner that it is brought gently, and at all points, in contact with the ascending stream of gas. The material with which the scrubber is filled may be of various kinds. The material most generally used is coke, which is the cheapest (indeed costless, because the coke, when 'foul,' i.e. thickly coated with tar, can be used in the retorts, or, in some works, as fuel in the furnaces), and also gives excellent results, owing to its porosity. The gas does not, indeed, pass through the pores of the coke, but the surface of this material being full of small cavities, the water lodges therein, and thereby comes in contact with the gas in a better manner than when brick or stone is used; but as soon as the surface of the coke becomes coated with tar, the peculiar advantage of this material is lost. Another kind of scrubber is one filled with tiers of thin deal boards placed on edge, over the surfaces of which the water drips, and the ascending gas is purified by coming in contact with those wetted surfaces. A scrubber somewhat similar, but less effective, consists of horizontal shelves of wood, so constructed as to keep their upper surface always covered with water to the depth of about ½ in., the water absorbing ammonia as the gas passes over it.

The apparatus for delivering water to the scrubber is at least as important as the material with which the interior of the scrubber is filled. The best kind of distributing apparatus is one which, by minutely dividing the water, and also wetting all parts of the scrubbing material equally, enables the purifying work to be done with the smallest amount of water. As a matter of economy, and also for perfect purification, it is desirable that there should be no pumping of the liquor back into the scrubbers: a process which can be dispensed with, if one of the best kinds of scrubber is used.

In order that the scrubbers may be kept in an efficient condition, it is necessary that the gas before entering them be properly condensed and cooled. The condensers ought to be of adequate size and efficiency to allow of all the tarry vapour being eliminated from the gas, and drawn off into the tar well; for if this be not done, a portion of the tar is carried forward into the scrubbers, and is deposited there instead of in the condensers. The effect of this is doubly disadvantageous. First, by choking up the interstices in the coke or brick scrubbers, so that the gas, instead of ascending equally through all parts of these scrubbers, forces a passage upwards by a comparatively few routes, and thereby does not come in a proper manner in contact with the purifying water. The other disadvantage is that the gas in such cases encounters an unnecessary amount of resistance in passing through those scrubbers, producing an inconvenient amount of 'back pressure,' which has to be overcome by the action of the exhausters, and also necessitating more frequent changes of the scrubbing material than would otherwise be required. Not less important is it to observe that, if the gas be not properly cooled in the condensers, the water in the scrubbers is raised above the ordinary temperature, whereby its power of absorbing ammonia is lessened; while at the same time the 'liquor,' after leaving the scrubbers, gives off into the air a larger portion of the ammonia with which it is charged than it would do at the ordinary temperature.

In gasworks where the size or efficiency of the scrubbers is not adequate for the work required of them, their action is supplemented by the use of sulphate of iron, or of sawdust moistened with sulphuric acid, either used separately in small purifiers, or introduced on trays in the oxide of iron purifiers employed for the elimination of sulphur. This supplementary process, however, although effective for the removal of ammonia, is (or at least ought to be) only a makeshift, rendered necessary by a want of room for the erection of additional or of larger scrubbers, or else owing to a temporary increase in the make of gas to a greater extent than the scrubbers can cope with; for these supplementary processes yield less profit to the companies than is obtained when the ammonia purification is effected solely by scrubbers.

The separation of ammonia from the gas is a most profitable process for the gas companies, and was adopted by them at first of their own accord, as a means of increasing their revenue. For example, let us suppose that thoroughly efficient scrubbers are used, *e.g.* such as those at the works at Blackfriars. In these works there are 5 scrubbers, costing for construction 500*l.* or 600*l.* each, or less than 3,000*l.* in all; but the value of the ammoniacal products obtained from these scrubbers is 3,000*l.* per

annum,[1] while the cost of labour per annum is virtually nothing, the scrubbers being self-acting, and the coke with which they are filled requiring to be changed (at the cost of about 10*l.* for each scrubber) only once in two or three years. Hence it appears that with the very best kind of scrubbers two-thirds of the cost of erection is repaid in a single year, and thereafter a large annual rental is received from them. In this respect ammonia purification stands in a different category from sulphur purification, the processes of which constitute a pure outlay on the part of the gas companies.

AMMONIA *as a Motive Power.* M. TH. FOUCAULT has invented an apparatus for raising water by means of ammoniacal vapour. The machine depends for its operation on the fact, that water at 15° C. absorbs 743 times its volume of ammonia, and gives it off again at 60° C.; that at 100° C. the tension of the vapour is 7½ atmospheres; that petroleum and ammoniacal vapour are without action upon each other; and that the same is true of petroleum and water.

The apparatus consists essentially of a heater, which is partially filled with a strong aqueous solution of ammonia. This heater is connected by pipes with the upper part of a closed reservoir, the lower part of the reservoir being connected by means of pipes and suitable valves with the steam or well from which, and the tank to which, water is to be raised. The reservoir contains a small quantity of petroleum, which forms a thin stratum on the surface of the water, and serves to keep the ammonia from contact with it, and, as the inventor expresses it, form a fluid piston. The operation is as follows:—Supposing the reservoir full of water, the temperature of the heater is raised by suitable means; ammonia vapour is given off, and passes over into the upper part of the reservoir, the stratum of petroleum preventing its being absorbed by the water there. A pressure is thus created in the reservoir, which forces the water out of, and up to the tank to be filled. When all the water has been forced out of the reservoir, the heater is cooled by removing the fire and allowing a jet of water from the tank to play on it. The water in the heater as it cools reabsorbs the ammonia from the reservoir, and thus creates a vacuum, which the water from the stream or well rushes up to fill, and so refills the reservoir. The heater is then again heated, and so on, as before. The inventor claims that the consumption of fuel is almost insignificant as compared with that of a steam-pump of the same capacity.

FOUCAULT also describes a modification of his apparatus to run by the heat of the sun, in which case the only expense is that of wear and tear, which is small, there being no moving parts. See SOLAR ENGINE.

AMYRIN. A resin, associated with, perhaps identical with, Elemi. See ELEMI.

ANDREWSITE. This mineral is found in Cornwall, in a vein of tin stone in the granite of the Phœnix Mine, Liskeard. It exists in globular and occasionally discoid forms, presenting a radiated structure, and in habit resembling Wavelite. These globules are of a dark green colour, with a somewhat glaucous cast, and from these there occasionally stand out crystals which are of a brighter green. It has been examined and described by Dr. C. LE NEVE FOSTER.

The vein-stone upon which Andrewsite occurs is a highly ferruginous quartz. The specific gravity of Andrewsite is 3·475. Its hardness is = 4. The streak is of a blackish green.

Dr. FLIGHT's analysis gives the following numbers:—

		Oxygen
Ferric oxide	44·639	13·392
Alumina	0·916	0·429
Ferrous oxide	7·109	1·579
Oxide of copper	10·857	2·188
Phosphoric acid	26·038	14·696
Water	8·761	7·814
Oxide of manganese	0·597	0·160
Lime	0·094	
Silica	0·493	
	99·554	

It has also been examined by Professor MASKELYNE, who found it accompanied by *Chalcosiderite.* He gives to these minerals the following formulæ:—

Andrewsite, $4Fe^2P^2O^8 + 2Fe^2H^6O^6 + CuH^2O^2$.

Chalcosiderite, $2Fe^2P^2O^8 + Fe^2H^6O^6 + Cu^3H^6O^6 + 4H^2O$.

On Andrewsite and Chalcosiderite, by Professor N. S. MASKELYNE, F.R.S. *Journal of the Chemical Society,* vol. xiii. See CHALCOSIDERITE.

[1] The coal carbonised at the Blackfriars Works in 1870 was 63,101 tons, each ton yielding 30 gallons of ammoniacal liquor of 10 ounce strength; the present selling price of the liquor being 5*s.* 5*d.* per butt of 108 gallons.

ANCHOR. (Vol. i. p. 157.) (*Ancre*, Fr.; *Der Anker*, Ger.) Vice-Admiral INGLEFIELD has invented a new anchor, which has been received at Portsmouth. It weighs 102 cwt., and is a modification of MARTIN's well-known self-canting anchor, with which the whole of the turret ships are now fitted. Like it, the shank and the crown are formed of one piece, but it has no stock nor 'steadying arms,' the weight thus saved being added to that of the arms, to give them more holding power. The new anchor also resembles the MARTIN anchor in the special feature that the arms are on parallel lines, and so grip the ground simultaneously. It differs from it, however, in the very important characteristic that, instead of the arms being made of one forging and working through the crown, they are formed of separate forgings, and are attached to the shank by a swivel pin. The advantages gained for the anchor are greater holding power and less liability to foul.

ANDALUSITE. A silicate of alumina, so called from having been first found in Andalusia, in Spain. It is found in many parts of Europe, in the mica slate of Kilkenny Bay in Ireland, in Argyleshire, and in Cumberland.

ANGLESITE, CUPREOUS. Cupreous sulphate of lead, found at Lead Hills, Lanarkshire, Roughten-Gill, in Cumberland, and at Linares in Spain. It consists of sulphate of lead, 75·4, copper, 18·0.

ANILINE COLOURS. (*Aniline*, Fr.; *Das Anilin*, Ger.) *Gris d'Aniline*, or *Nigrosin*. 'With this colour the silk dyers produce all their greys, dark blues, plum colours, and Russian green, at prices very little exceeding the wood colours. The same colour beck is used for days. The gris d'aniline, soluble in spirit, is preferable to that soluble in water, as the latter is apt to come up flat in the darker shades. The operation is performed at a boil with soap and sulphuric acid.

'With the addition of orchil and young fustic all conceivable shades of grey, mauve, and olive greens are produced. For dark green, turmeric is added, or a combination of gris d'aniline, aniline blue, and turmeric is used. The green shades may be brightened by topping with picric acid in a fresh beck. Dark blue is obtained with gris d'aniline and aniline blue.

'In dissolving the colour, proceed as for other aniline colours soluble in spirit, and the solution is filtered for use.

'To 1 kilo. of silk are taken, half a gallon of strong soap-lye (*cuite*), the beck is made up with water, 65 grams of sulphuric acid are added, and the whole heated to 60° C., and afterwards raised to a boil, without which the shades will be uneven.'—REIMANN's *Färber Zeitung*, No. 11, 1875, as quoted in the *Chemical News*.

The Production of Aniline Colours without the use of Arsenic. (See ANILINE RED, vol. i. p. 183.) M. COUPIER of Paris appears to have been the first who succeeded in producing *fuchsine* by the action, at a suitable temperature, of hydrochloric acid and iron in small quantities on pure aniline and nitrotoluol. SCHÜTZENBERGER confirmed COUPIER's experiment, and showed that the aniline red obtained by this process was identical with that usually manufactured, and that the yield was greater than when arsenic was employed. In 1872, MEISTER, LUCIUS, and BRÜNING, of Hoechst, Germany, commenced to work this process on a large scale. Since that time the company for the aniline manufacture at Berlin have erected new works, where no arsenic is used in the manufacture of aniline colours. This company are working COUPIER's process with several modifications, and produce from four to six hundred pounds of fuchsine a day, of unrivalled beauty, purity, and strength. The fuchsine is said to be purer and stronger than that made by the aid of arsenic acid, and is the pure hydrochlorate of rosaniline.

In a letter in the *Chemical News* of February 19, 1875, MEISTER, LUCIUS, and BRÜNING state that since the end of 1872 they 'have not been using any arsenic acid in our works at all,' and that their fuchsine and magenta, as well as all other colours manufactured by them, are produced without the employment of arsenic acid.

The same firm write to the *Moniteur Scientifique* of Dr. Quesneville, for August 1875, saying that they now do not employ arsenic in their establishment under any form, and that they guarantee all their dyes to be free from that dangerous substance.

This is an instance of catering to the false feelings of the ignorant for the sake of a trade reputation. The arsenic does not exist in the aniline dyed articles, in anything approaching to a dangerous condition. This firm, no doubt, produces the aniline colours, or a certain number of them, as many other firms do, without the use of arsenic, but there is a want of faithfulness in attributing any danger to the employment of this mineral to effect a chemical change.

The TURNER COMPANY uses a modification of COUPIER's system for producing aniline colours (especially magenta), without arsenic; and it is hence very suitable for the preparation of other derivatives. 'These colours may be used, it is said, for

liqueurs, syrup, confectionary and the like, but perhaps this is erring in the extreme in another direction.

The Electrolysis of the Derivatives of Aniline. By electrolytic action a series of interesting changes are produced upon the salts of aniline. In the *Comptes Rendus*, M. F. GOPPELSROEDER gives the results of his investigations. Quite differently from the salts of aniline, he says, behave the salts of crystallised *toluidin*, and also the salts of *pseudo-toluidin*. The former furnish at the positive pole a brown matter soluble in alcohol, and dyeing silk and wool a yellowish brown.

Pseudo-toluidin distinguishes itself from aniline, since on electrolysis we obtain at the positive pole a reaction which agrees with that which is obtained by chloride of lime. It forms a violet colour, which is changed by dilute nitric acid, or by the solution of permanganate of potash to a red colour. The mixtures of the bases, aniline, toluidine, and pseudo-toluidin, behave differently from the separate bases. Thus an aqueous solution of one molecule of hydrochlorate of aniline with two molecules of hydrochlorate of toluidin, is coloured red at the positive pole. Commercial aniline imperfectly saturated with sulphuric acid, in an aqueous solution, with an addition of ammonia, gave at the dehydrogenising pole, as a principal product, a red colour, and as a secondary product, a violet colour.

Methylaniline gives, when employed in the form of its salts, a violet colour at the positive pole.

Diphenylamin gives, if one of its salts is submitted to electrolysis at the positive pole, a blue product soluble in alcohol.

Mixtures of *diphenylamin* and of *ditoluylamin*, and *phenyl-toluylamin*, such as are employed to produce the blue colours called *Diphenylamin blue*, or according to theory, *Triphenylated rosanilin blue*, give, if submitted in the state of salt to a galvanic current, this beautiful blue colour soluble in alcohol.

Methyl-diphenylamin, which yields with different oxidising agents a blue or violet colouring matter, undergoes the same transformation in the electrolytic way.

ANILINE BLACK. M. COQUILLION (*Comptes Rendus*, August 1875) published a memoir on the aniline blacks. Upon this M. A. ROSENSTIEHL remarks, that in the present state of science when we wish to obtain aniline black, upon any tissue economically, the simultaneous action of a chlorate and a metallic substance is indispensable.

Practice has selected copper for blacks to be developed at about 250° Fahr., and iron for those which are to be steamed at 100°. Aniline black may be obtained upon the tissues, by the mere use of active oxygen with the intervention of a metal or a chlorate. M. COQUILLION has shown how this result may be obtained without the chlorates. The fact observed is an elegant demonstration of the effect of active oxygen upon the salts of aniline. M. M. ROSENSTIEHL, *Comptes Rendus hebdomadaires*, December 1875.

M. ANTONY GUYARD shows that aniline black is the result of the action of the products of the destruction of chloric acid upon aniline. In other words, '*Aniline black is the product of the incomplete combustion of aniline and chloric acid in the midst of a fluid.*'

Amongst the metallic salts the most remarkable is the chloride of vanadium. One part of this salt has the power of transforming 1,000 parts of muriate of aniline into aniline black in the presence of alkaline chlorates. M. GUYARD says: 'The chemical part played by *mycoderms* in fermentation is well known. Vanadium may be said to be the mycoderm of aniline, which it transforms into aniline black.' 'This powerful action of vanadium is due to a curious property which alone it possesses in so marked a degree. It absorbs and gives up oxygen with equal facility, its reducing power being nearly equal to its oxidising power. *It is a mineral ferment.*' [The italics are GUYARD's. This sort of reasoning by analogy is always dangerous in science. ED.]

All the aniline blacks are liable to turn green by exposure; and it has been a problem which cannot be said to be as yet solved, to determine the cause of this tendency to turn green, and to ascertain the best method for preventing this defect.

The greening of the aniline black is not a deoxidation. GLANZMANN says, that the fastness or stability of aniline black is in direct proportion to the quantity of it which is applied to a given portion of cloth.

Blacks from aniline salts become green when brought in contact with acids or acid salts. Alkalies restore the black colour.

To obtain a fast aniline black: As large an amount as possible of the neutral salts of aniline must be in the colour, representing from 10 to 16 oz. of pure aniline per gallon of colour. The oxidation must be quite complete before washing off or

raising. A black made from a mixture of chlorate and muriate of aniline showed the best colour as to excellence and stability.

Numerous chemists have been employed in the investigation of this peculiar and annoying change, but it cannot be correctly said that they have arrived at any satisfactory result. One thing appears to have been made out. The method of formation of the black and *its intensity*, have an influence upon its greening, that is, *the weaker the black the more readily it becomes green.*

A black oxidised at a low temperature is more sensitive than one oxidised at a high temperature. A steam black made with prussiate of ammonia, containing 80 of aniline to 1,000 of colour, shows a resistance to this change beyond any other, according to the extensive experiments of DEPIERRE. M. F. LAMY, *Industrial Society of Rouen*; M. R. GLANZMANN, *Note upon Black from the Muriate of Aniline*; GIRARD and DELAIRE, *Dictionnaire de Chemie* and *Moniteur Scientifique*; DEPIERRE, *Dictionnaire de Chemie* and *Moniteur Scientifique*; *The Textile Colourist*, vol. ii.

M. WEHRLIN prepares the aniline-ferro and ferro-cyanides for aniline blacks in a state of purity with hydro-ferrocyanic acid, obtained by the action of tartaric acid upon yellow prussiate of potash. Aniline ferro-cyanide forms their colourless laminæ, which gradually become yellow, and turn black if exposed to higher temperatures. Aniline ferri-cyanide forms deep violet laminæ. It is slightly soluble in ether and carbon bisulphide, but dissolves in alcohol, aldehyd, and water.

M. SCHLUMBERGER prepares aniline ferro-cyanide by utilising its slight solubility in cold water. He takes 2 parts of hydrochloric acid at 19° Baumé, and 2 parts of aniline, and dissolves separately 2·4 of ferro-cyanide of potassium in 4·2 of boiling water. When this solution has cooled down to 56° C., the hydrochlorate of aniline, quite cold, is added. After a time aniline ferro-cyanide is deposited, and the chloride of potassium remains in solution. The aniline salt is drained and preserved in a moist state. The moist salt may be kept several days without change of colour if it is protected from the light. To make the black, 10 per cent. of this salt is added to thickened chlorate of aniline.

M. A. KIELMAYER prepares chlorate of aniline as follows: 5 parts of crystallised tartaric acid are dissolved in 10 parts of boiling water, 4 parts of chlorate of potassium are dissolved in other 12 parts of boiling water. These solutions are mixed while hot, and 3 parts of aniline are added with 20 parts of cold water. The solution becomes a pale yellow, and stands at 6¾ B. A solution of hydro-ferrocyanic acid is obtained by treating parts of the ferro-cyanide of potassium with 3 parts of sulphuric acid, diluted with 14 parts of water. After some days the yellow colour disappears, and sulphite of potash deposits. To 100 parts of this solution of hydro-ferrocyanic acid are added 128 parts of water and 20 of aniline. For a steam aniline black take 34 parts of this solution of chlorate of aniline, 12 parts of the solution of ferro-cyanide of aniline, 34 parts of water, 12 parts of gum tragacanth mucilage, containing 128 grains of gum per 1¾ pint of water.—*Bulletin de la Société Chimique de Paris*, January 20, 1875.

By Electrolysis. On electrolysing sulphate of aniline for 24 hours, the positive electrode was found covered with a black deposit, which after treatment with ether and alcohol and drying, gave a black insoluble substance.—M. J. J. COQUILLION, *Comptes Rendus*, t. lxxxi.

Aniline black may thus be formed, as has been shown by the electrolysis of its salts. It is generally known that aniline black may be obtained by dissolving a salt of aniline in water, then adding chlorate of potash and sulphite of copper, or sulphate of iron. It is generally thought that the presence of a metallic salt is absolutely necessary. COQUILLION proposes to form aniline black without the intervention of any metal, simply by the action of nascent oxygen upon certain salts of aniline. This process is as follows:—

If a concentrated solution of sulphate of aniline is submitted to the action of two Bunsen elements with platinum electrodes, the positive pole is soon covered with a violet blue pellicle, greenish in certain parts. If the experiment is prolonged for from twelve to twenty-four hours, there is found on the positive pole a black adhesive substance. On treating this substance with ether and alcohol, and drying it in the stove, there remains a black amorphous matter, with greenish reflections, insoluble in most solvents. If this substance is treated with sulphuric acid, and spread out in a thin layer, it assumes a greenish colour, but in contact with alkalies it returns to a velvet black. Nitrate of aniline gave also, under like treatment, a black deposit, which in contact with alkalies took a velvety appearance, but was decomposed by sulphuric acid, with a maroon brown colouration. Hydrochlorate of aniline gave a clotty black product at the positive pole, but in this case the results were probably complicated by nascent chlorine. Acetate of aniline gave a clammy substance at the

positive pole. Thus, it appears that aniline black may be obtained without the presence of any metal, and that the salts of aniline behave in different manners in the presence of nascent oxygen. *Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, August 30, 1875.

Synthesis of Aniline Black. The slips of carbon which serve as electrodes were exposed for 3 hours to a current of chlorine in a porcelain tube heated to redness. They were then boiled in nitric acid, again submitted to the action of chlorine, and washed in distilled water, when they might be regarded as pure. These points were 1 decimètre in length. To effect the electrolysis, two platinum wires were coiled round their upper parts, and were connected with the two Bunsen elements made use of in these experiments. As soon as the lower extremities of the carbon points were plunged in the salt of aniline, the positive electrode became covered with black, whilst hydrogen escaped from the negative pole. It seems, therefore, beyond doubt that aniline black may be produced without the action of any metal. This fact being established, it remains to be seen which salts of aniline are capable of yielding aniline black. The hydrochlorate and the sulphate alone seem able to produce the black under practical conditions. The author has previously shown that these two salts when submitted to electrolysis yield after the lapse of 24 hours a paste-like mass surrounding the positive electrode. This mass, when washed and dried, is soluble in concentrated sulphuric acid. It has a blackish violet tint, analogous to a solution of violaniline in the same acid; but if water be added to the dissolved black, a greenish mass is immediately precipitated, a phenomenon which does not occur in the case of violaniline. This is an important character, which seems to distinguish aniline black. This reaction may be obtained even with a slip of dyed cotton. The greenish flakes, however, resume their original black colour if the acid is neutralised with ammonia or potash. Two other salts of aniline, the arseniate and the phosphate, or rather a mixture of phosphates, likewise yield aniline black. With two Bunsen elements, however, the operation is slow and difficult. The solution of these salts is syrupy, and after the lapse of 12 hours there are obtained merely small quantities of black, which likewise is soluble in concentrated sulphuric acid with a red violet colour, and on adding water deposits greenish flakes. The colours, however, do not appear to be identical with those obtained from the hydrochlorate and the sulphate. These salts are not likely to be used in practice. The black from the nitrate of aniline and that from the acetate do not present this reaction, and their molecular constitution is probably different. Thus, from a theoretical point of view, we see that it is possible to form aniline black by direct synthesis, and that the same method may doubtless realise analogous syntheses. From a practical point of view, the results are also not without importance. For the success of the operation the solutions ought to be concentrated. Practical men should therefore add as little water as possible, and keep within the limits which experience will easily indicate. The other laws of electrolysis have also their applications. Every cause which tends to separate the molecules assists the reaction; a more elevated temperature will therefore be favourable, but to ensure uniformity of shade, the temperature must be uniform also. A diminution of pressure will have no analogous effect. The printer must therefore beware of employing, as was formerly done, cast-iron drums, where the gases from the reaction finding no escape, augment the pressure, and thus hinder the formation of black.

MM. Koechlin Frères thus avoid the greening of aniline blacks:—

Aniline blacks, if submitted to acid reducing agents, such as sulphurous acid and sulphuretted hydrogen, take a greenish colour, due to their more or less complete conversion into emeraldin, which is deep blue in an alkaline state, but is rendered green by the slightest trace of acid. There is a product more highly oxidised than aniline black, which is no longer transformed into emeraldin by reducing agents, whether acid or alkaline, which is obtained as follows:—Aniline black, printed and fixed, is finished as usual, and then submitted in a beck to an acid oxidation at a temperature above 75°. It is then merely required to soap and wash the pieces. Among the oxidisers which give the best results are the salts of ferric oxide, chromic acid, and the chlorate of ammonia. The ferric solution is prepared from a persalt of iron, mixed with 1 to 1½ times its weight of sulphuric acid at 66° B., to prevent the iron from being fixed on the fibre. This solution is employed in the proportion of 1 to 2 grams per litre to a dye beck for 6 to 8 pieces, which are passed through it from half-an-hour to an hour at 80°. Ferrous sulphate, 20 kilos dissolved in 60 to 70 litres sulphuric acid at 66° B. may be employed. To this are added 5 kilos. of bichromate of potash, dissolved in 15 to 16 litres of sulphuric acid at 66° B.; from 4 to 5 litres of this liquor are taken and applied as above.

M. Jeanmaire uses hydro-ferricyanic acid; by its use the resulting blacks have lost all sensibility to sulphurous acid. He also employed another ferric compound—the acid nitrate. In it the blacks acquire the wished-for solidity, and those even

which had turned green are rendered incapable of 'greening.' Other nitrites have been used by chemists with equally good effects. On becoming incapable of turning green, the black attains its greatest beauty—the maximum of colouration coinciding with the maximum of aniline black used.—Dr. QUESNEVILLE, *Moniteur Scientific*, December 1876.

G. WITZ has shown (REIMANN'S *Farber Zeitung*, No. 1, 1875) that it is possible to discharge aniline black. He treats the aniline black with an acidulated solution of permanganate of potash, when peroxide of manganese is deposited upon the fibre. This is then treated with a solution of oxalic acid, which removes the manganese, and leaves the tissue perfectly white.

The solution of permanganate may be thickened with infusorial silica and printed upon the tissue so that a white design can be printed on a black ground.

ANILINE INKS. For a *red ink*, it is recommended that 1 part of diamond fushin or rosein be dissolved in 150 parts of boiling water.

For a *blue ink*, 1 part of bleu de Paris dissolved in 200 parts of hot water.

For a *violet ink*, 1 part of HOFMANN'S blue violet dissolved in 300 parts of water.

For a *green ink* dissolve 1 part of iodine green in 100 parts of boiling water.

These inks are not suited for copying; but they dry quickly, and they never clog.—M. C. H. VIEDT, *Moniteur Scientific* du Dr. QUESNEVILLE, March 1876.

Aniline Black and Marking Ink. Dissolve in 60 grams of water 8·52 grams of crystalline chloride of copper, 10·65 grams of chlorate of soda, and 5·35 grams of chloride of ammonium. Then dissolve 20 grams of hydrochlorate of aniline in 30 grams of distilled water, and add 20 grams of mucilage made of 1 part of gum arabic to 2 of water, and 10 grams of glycerin. If 4 parts of the aniline liquid are mixed with 1 part cold of the copper solution we obtain a greenish liquid, which may be used at once for marking linen; but as it decomposed in a few days, it is better to preserve the two solutions separately. The writing is at first greenish, but is blackened by being held in a jet of steam; a dry heat renders the tissue brittle.—Dr. JACOBSEN, *Moniteur Scientific*.

ANNABERGITE, or *Nickel Bloom.* A compound of arsenic and oxide of nickel, quite soft, and of an apple green colour. See NICKEL.

ANORTHITE. (Vol. i. p. 101, and FELSPAR, vol. i. p. 334), and LAVA.

ANTHRACEN. (Vol. i. p. 101.) The brief notice of ANTHRACEN given in Volume i. was written just as this remarkable substance was beginning to attract attention. Since that period there has been a considerable development in this peculiar industry. The extensive chemical examinations which have been made in this country and more especially in Germany will be found recorded very fully in WATTS'S *Dictionary of Chemistry*. We have only to deal with the manufacturing processes.

Anthracen is most readily formed from those parts of coal tar which boil at the highest temperature, of which, according to GRACE CALVERT, it forms only 1 per cent. According to M. REIMANN, the tarry oils from the Swabian lias slate are rich in anthracen.

If the distribution of the coal tar is pushed so far as to produce 10 or 15 per cent. more oil, a hard pitch remains of little or no value, whilst the anthracen obtained, according to the nature of the coal, may amount to from $1\frac{1}{2}$ to 8 per cent. of the heaviest oils. Its separation from the heavy oils and its purification are very tedious. The purest product obtained on a moderately large scale contained 40 per cent. if cold pressed, and 70 per cent. if hot pressed. The manufacture of anthracen from coal tar is conducted as follows:—If the coal tar is distilled in the usual manner, it yields on the average per ton about 455 to 490 fluid ozs. of ammoniacal liquor, and 1,015 to 1,050 fluid ozs. of very light oil containing benzol, 3,150 to 3,000 fluid ozs. of light oils still containing a little benzol and fit for use as lamp naphtha.

If the process is broken off at this juncture there remains in the still the so-called asphalt, a black mass, semi-liquid even when cold, and consisting of heavy oils and of pitch. If the distillation is carried further, creosote oils are obtained, and the residue in the still is then fluid enough to be run off when hot; but on cooling, it congeals to black shining hard pitch.

The distillation of the heavy oils, especially if it is intended to obtain lubricants and anthracen, may be approximately divided into 2 or 3 processes.

The distillate first passing over, if on being allowed to cool deposits naphthalin in crystals, is collected and used for impregnating wood, for which it is peculiarly fitted, on account of its high percentage of phenol (carbolic acid). When the distillate remains fluid on cooling, it is collected in another receiver, and used as a liquid lubricant.

After a time the distillate on cooling no longer remains fluid, but assumes a thick paste-like consistence, due to the deposit of paraffin. This produces the so-called

'green grease,' and is the principal material for the manufacture of anthracen. This is subjected to heavy pressure, or it is placed in the centrifugal machine. By these methods the greater part of the oils is removed, leaving a cake rich in anthracen.

To obtain the largest possible yield of anthracen from this pitch certain precautions are absolutely necessary. The still must be greater in breadth than depth, and the distillation must not be carried on too rapidly. The pipe for the exit of the vapours must be of large size, and must open into the still only 1½ or 2 decimètres (about 6 or 7 in.) above the surface of the boiling pitch, and then bend immediately downwards, so that the heavy vapours scarcely require to rise, but may flow out easily and at once sink downwards.

The distillation of the soft pitch is conducted as follows:—The iron still is filled with melted pitch, heat being at once applied. As soon as the distillation begins, the fire is moderated in order to obviate boiling over. When a certain quantity of heavy oil has passed over, an equal volume of melted pitch is introduced through a vertical tube, which passes through the dome of the still, and dips into the boiling pitch to half its depth. The still is not to be heated too violently, lest the pitch should burn. Towards the end of the operation, which may be known by the condensation pipe growing cold, the fire is allowed to go out.

By whatever means the crude anthraceniferous mass has been obtained, it must be submitted to a process of purification as follows:—

(*a*.) Leaving the heavy oils for some days in a cool place, that the anthracen may be deposited as completely as possible.

(*b*.) Filtration in a filter press, to separate the liquids from the solids. It is then put into the centrifugal machine.

(*c*.) Pressing the mass with great care after it has been removed from the centrifugal machine. After pressure, the mass should be perfectly dry, capable of being powdered and sifted.

(*d*.) Washing the finely ground product with benzol or light petroleum oils. If the lixiviation takes place at a boiling heat, the anthracen which is dissolved by the benzol or petroleum is redeposited as the solvent cools.

(*e*.) The lixiviated anthracen is then placed in the centrifugal machines, or strongly pressed and removed to the drying room. Anthracen containing 25 to 50 per cent. of actual anthracen is ground fine, sifted, and then placed in the washing cylinder with an equal weight of naphtha, and stirred. The longer it is washed the better. The main point is that the crude anthracen must be ground as fine as possible, and that all its particles must be brought in contact with the naphtha.

Anthracen cakes thus obtained must be comminuted as finely as possible preparatory to further treatment. This is best done by sublimation. Anthracen at above 60 per cent. may be sublimed directly by means of air deprived of its oxygen, by being passed over ignited charcoal, or by superheated steam.

To obtain pure anthracen it is preferable to sublime at the lowest possible temperature, and to wash subsequently with ether, which dissolves the adherent yellow substances. Or the anthracen may be dissolved in benzol, and the solution may be bleached by exposure to sunshine. In the latter case anthracen separates out on cooling in colourless crystals, possessing the splendid blue fluorescence described by FRITZSCHE. Still the anthracen purified in this manner contains an admixture of para-anthracen. The best way of obtaining anthracen is the reduction of its derivatives with zinc powder.

The following methods have been used for the determination of anthracen:—

1. *The alcohol process*, washing in boiling alcohol.
2. *Petroleum and bisulphide of carbon process.* PERKIN'S *method.*
3. COHN'S *bisulphide of carbon method.*

LUCAS has compared the determination of anthracen by LUCK'S process with bisulphide of carbon analysis, and has tabulated his results:—

No	By the bisulphide of carbon process	By conversion into anthraquinon	Difference
1	9·20	11·90	+2·70
2	16·00	16·40	+0·40
3	24·50	26·10	+1·60
4	34·00	27·80	−6·20
5	35·00	28·20	−6·80
6	35·00	29·67	−5·33
7	35·00	33·33	·62
8	40·50	38·00	2·50
9	43·00	33·80	0·20

No.	By the bisulphide of carbon process	By conversion into anthraquinon	Difference
10	49·00	34·24	14·76
11	67·40	44·51	12·89
12	58·00	41·50	16·50
13	59·00	44·51	14·49
14	59·50	39·47	20·13
15	60·00	37·66	22·34
16	60·00	42·50	17·20
17	64·12	48·79	15·23
18	65·00	47·08	17·92
19	67·00	46·22	20·78
20	73·00	49·22	23·78

Anthracen, its Constituents, Properties, Manufacture, and Derivations, by G. AUERBACH. Translated by WM. CROOKES, F.R.S. See ANTHRACUINON.

Anthracen and its Derivatives.

Anthracen	$C^{14}H^{10}$
Anthracenhydride	$C^{14}H^{10}H^{2}$
Anthracenhexahydride	$C^{14}H^{10}H^{6}$
Bibromanthracen	$C^{14}H^{8}(Br^{2})$
Bibromanthracentetrabromide	$C^{14}H^{8}Br^{2}Br^{4}$
Tribromanthracen	$C^{14}H^{7}Br^{3}$
Tetrabromanthracen	$C^{14}H^{6}Br^{4}$
Bichloranthracen	$C^{14}H^{8}Cl^{2}$
Trichloranthracen	$C^{14}H^{7}Cl^{3}$
Tetrachloranthracen	$C^{14}H^{6}Cl^{4}$
Anthracen carbonic acid	$C^{14}H^{9}CO^{2}H$
Methylanthracen	$C^{15}H^{12}$
Dibrommethylanthracen	$C^{15}H^{10}B^{2}$
Dimethylanthracen	$C^{16}H^{14}$
Anthraquinon	$C^{14}H^{8}O^{2}$
Bibromanthraquinon	$C^{14}H^{6}Br^{2}(O^{2})$
Monobromanthraquinon	$C^{14}H^{7}Br(O^{2})$
Bichloranthraquinon	$C^{14}H^{6}Cl^{2}(O^{2})$
Mononitroanthraquinon	$C^{14}H^{7}(NO^{2})O^{2}$
Dinitroanthraquinon	$C^{14}H^{6}(NO^{2})^{2}(O^{2})$
Monoamidoanthraquinon	$C^{14}H^{7}(NH^{2})O^{2}$
Diamidoanthraquinon	$C^{14}H^{6}(NH^{2})^{2}O^{2}$

The azo-compounds of anthraquinon are of great chemical interest, but they are not as yet of much commercial value. They are therefore omitted, since all who desire to study these compounds should refer to WATTS's *Dictionary of Chemistry*, and to *Anthracen*, by AUERBACH.

Anthracen Production.—Dr. FREDERICK VERSMANN gives, in the *Chemical News* for November 17, 1867, a sad account of the anthracen manufacture. The production of anthracen far exceeds the demand. Up to the end of 1877 there will be produced in England alone, including the present stock, at least 1,400 tons of pure anthracen. The requirements of all the alizarin works do not exceed 2 tons a day, or 600 tons a year. The Paris Gas Company produces at least 250 tons a year. Belgium, and especially Holland, is active in the manufacture. America sends some to Europe, so that at the end of 1877 there must be an excess of many hundred of tons.

ANTHRACEN OIL. The difficulty of obtaining pure anthracen oil and of obtaining anthracen from it is well known. Mr. A. McDONALD GRAHAM solves the problem. He writes :—'At present, I believe, there are two methods of extracting the anthracen from the filtered oil employed by tar distillers. One of these methods consists in subjecting the oil to fractional distillation, retaining only that portion of the distillate coming over between 300° and 360° C. Some manufacturers, however, prefer to redistil the oil in a cast-iron retort, rejecting the first portions, and continuing the operation until the residue is coked.

'As to the first of these methods, viz. purification by fractional distillation, anyone who has made the trial will, I think, agree with me that it is a work of some difficulty and expense, and not to be attempted if an easier method can be found.

'The second mode of operating on the oil, viz. distilling to a coke, has the merit of extracting all the anthracen, and was, I believe, in general used by tar distillers when

the anthracen was sold by the petroleum and bi-sulphide test. The quantity of real anthracen contained in the distillate of course varies according to the nature of the oil operated on; but it is usually very small, amounting on the average to about 12 per cent.

'The method which I have found to give good results, and which would, I think, at once suggest itself to anyone who had had any experience in such matters, is to condense the oil, and allow the residue to cool, and the anthracen to crystallise out as at first. In order to do this, I place, say 1,600 gallons of the filtered oil in a wrought-iron still, and distil until crystals of anthracen begin to appear in the distillate on cooling: the distillation is then stopped, and after the temperature of the remainder has become sufficiently reduced, I run it out into a tank, and allow the liquid to cool when the anthracen crystallises out in large quantity. A second and a third condensation can be made if necessary, but I have usually found that the oil was sufficiently exhausted in one operation.

'The solid portion deposited in the tank will now be found to contain at least 17 per cent. of real anthracen, and will be much easier to treat either by fractional distillation or washing, being comparatively free from hydrocarbons coming over at a higher temperature than anthracen. I have found no difficulty in obtaining 36 per cent. anthracen by this method, and others by care may arrive at better results.

'Should washing be resorted to, it must not be overlooked that the crystals of all the substances dissolved are deposited according to their solubility in the dissolving medium, and by acting upon a knowledge of this fact the best results may be obtained.'—*Chemical News*, March 10, 1876.

ANTHRACITE. (*Anthracite*, Fr.; *Die Kohlenhornblende Glanzkohle*, Ger.) Mr. Edward T. Hardman, of the *Geological Survey of Ireland*, has published some remarks upon the formation of anthracite, which are worthy of all attention. The following abstract gives the views entertained:—

He considers coal to be the ultimate result of the alteration of woody matter by the elimination of successive portions of carbon, hydrogen, and oxygen.

Leaving out the ash and other incidental ingredients, the following table is given, as calculated from various analyses:—

Cellulose	$C^{36}H^{60}O^{30}$
Peat	$C^{34}H^{34}O^{13}$
Lignite	$C^{30}H^{28}O^{6}$
Splint Coal	$C^{26}H^{20}O^{2}$
Hard Coal	$C^{25}H^{20}O^{4}$
Steam Coal	$C^{24}H^{18}O$
Anthracite	$C^{24}H^{8}$
Graphite	$11C^{2}+C^{2}H^{8}-2CH^{4}$

The following table will serve to show approximately the manner in which the gases have been eliminated:—

Loss undergone by Cellulose in passing into various kinds of Coal.

Passing into	CH^4	CO^2	H^2O	C^2H^4 (Olefiant gas)
Peat.—Cellulose loses	...	2	13	...
Lignite "	1	5	14	...
Splint Coal "	3	7	14	...
Hard Coal "	4	7	15	...
Anthracite "	5	7	16	...
Anthracite coal altered by strong heat	3	4	20	2[1]

'Anthracite might result in time from the gradual elimination of the volatile matter of coal; and some of the oldest anthracites may have been so formed.' Dr. T. Sterry Hunt considers that while the alteration is in many cases due to 'subterranean coking,' it may often have been the result of decomposition at ordinary temperatures. Mr. Hardman says, 'It will be found that, in nearly every instance where anthracite occurs, an outburst of igneous rock, *of later date than the anthracite beds*, exists either in the immediate vicinity, and unmistakably altering the coals, or is protruded sufficiently close to it to warrant the assumption that some of it rises near enough to have affected the change.'

A synopsis is given of examples which appear to support the author's views.

[1] A product of the destructive distillation of coal.

IRELAND.—*The conversion of ordinary Coal into Anthracite by Heat.*—At Ballycastle, county Antrim, a thick bed of basalt has penetrated the coal measures, and has altered the bed above it to a true anthracite. In the Leinster coal field, which contains perhaps the purest anthracite of any district, the beds show no signs of disturbance. The inference is, that subterranean heat has produced the change.

SCOTLAND.—The few examples that are found are invariably associated with igneous outbursts. The coal fields so affected are the *Clyde Basin*, *Fifeshire*, and the *Ayrshire* coal fields. The last contains the well-known 'blind coal' of Kilmarnock, and in some places the anthracite has been rendered quite columnar by the thermal influence of trap dykes.

ENGLAND.—Many of the northern coal fields are penetrated by trap dykes, and whenever these come sufficiently near the coal it has lost its bitumen, and approaches more or less to the character of anthracite—as in parts of Durham and Northumberland, also in South Staffordshire, where the '10-yard coal' has been altered in more than one place to anthracite by the intrusion of masses of trap.[1]

SOUTH WALES.—In South Wales the coal, bituminous on the eastern side, begins to change its character about the Neath Valley, near Merthyr Tydvil, becoming only semi-bituminous. This alteration goes on towards the west, until at last, in Pembrokeshire, only pure anthracite remains.

DE LA BECHE refers to the occurrence of trappean and granitic rocks—in Pembrokeshire, in the neighbourhood of Rosemarket and the northern arm of Milford Haven, —of more recent age than the coal measures.

DEVONSHIRE CULM MEASURES.—Referred to the action of the granitic masses and trap rocks of Dartmoor and of Lundy Island.

FRANCE, BELGIUM.—In France the numerous small coal fields east of Auvergne contain for the most part anthracite, and are connected with outbursts of igneous rocks. The district lying around the mountains of Forez have been specially subject to igneous action, and the coals have been altered to anthracite, as in the region extending from Vichy to St.-Etienne. Here in the valley of the Sichon the coal bearing rocks are penetrated by porphyritic rocks, and much altered, the coal being anthracite. In *Dauphiné* and *Savoy* anthracite is found associated with altered schists and sandstone.

Mons Coal Field.—The only anthracite found in Belgium occurs in this field, due probably to the action of the porphyritic rocks between Liége and Mons.

ITALY.—The anthracite coal of Demonte, near Cuneo, in the Italian Alps, near the eruptive rocks of Montiois. See COAL for further description.

SAXONY.—At Chemnitz the coal measures are penetrated by the Permian porphyries, which accounts for the alteration of the '*Russkohle*' to a partial anthracite.

SILESIA.—Here the coal strata are invaded by igneous rocks, and we have anthracite. The same effect is seen at *Waldenburg*, at Osnabrück. Again in *Hesse*, on the *Meissner*, the basalt has converted the tertiary coal into anthracite.

STYRIA.—In the *Stangen* Alps anthracite has been produced from the coal by igneous action.

PRUSSIA.—The coal is gradually changed from bituminous to anthracitic by the proximity of igneous rocks.

AMERICA.—The great *Appalachian Coal Field* is some 180 miles broad and several hundred long. It is evenly bedded towards the west, the coal being bituminous. Towards the east the beds begin to roll, and are finally contorted, and the coal gradually becomes anthracitic. The large dykes of trap rock extending through Pennsylvania into North Carolina are supposed to produce this change.

Massachusetts and Rhode Island.—'This highly metamorphosed anthracite is clearly the north-eastern extension of the Appalachian coal field. The measures have been in some cases completely altered to quartzites and schists, and the coal even to graphite. It appears likely that this locality was a focus of igneous action.'

Other similar changes are shown to exist in other parts of North America and in Mexico.—*On the Origin of Anthracite*, by EDWARD HARDMAN, F.C.S.—*Journal of the Royal Geological Society of Ireland*, vol. iv. Part iii. New Series.

ANTHRACITE, AMMONIA IN. From examinations of several samples of the coal which have been made in the Bussey laboratory it appears that some soluble compound of ammonium is often contained in Pennsylvania anthracite, such as is used for fuel in that vicinity. Some idea of the significance of the figures given by the examinations may be gained by contrasting the amounts of ammonia in anthracite with the amounts of ammonia that have been found in soils. Thus, while it appears that 100 grams of anthracite ordinarily contain from 0·0002 to 0·0008 or even 0·00566

[1] See Jukes on 'The South Staffordshire Coal Field.' *Memoirs of the Geological Survey of Great Britain on the Influence of Igneous Rocks upon the Coal.*

gram of ammonia, the experiments of KNOP and WOLF, made upon 5 different kinds of soil, show no more than from 0·00012 to 0·00087 gram of ammonia for 100 grams of anhydrous earth. The results obtained from the anthracite and from the soils are shown in detail in the following tables:—

Recapitulation of the Experiments on Anthracite.

No. of the Experiment	Ammonia per cent.	No. of the Experiment	Ammonia per cent.
I.	0·00217	VIII.	0·00022
II.	0·00080	IX.	0·00033
III.	0·00566	X.	0·00040
IV.	0·00615	XI.	0·00018
V.	0·00050	XII.	0·00020
VI.	0·06020	XIII.	0·00410
VII.	0·00150	XIV.	0·00055

Knop and Wolf's Experiments on Soils.

Kind of soil	Ammonia per cent. in dry soil
Very poor, light, sandy soil	0·00077
Soil rich in humus from a beech wood	0·00087
Sandy loam from hardwood forest	0·00012
Mould from forest on bank of river Elster	0·00050
Poor red sandy loam from a ploughed field	0·00017
Average	0·000546

ANTHRAFLAVON. Anthraflavon itself is a mixture of 2 isomers of alizarin, distinguished by their behaviour with bases. The one forms a soda salt very soluble in water; it dissolves in baryta water, which it colours a deep orange yellow, combines with gelatinous alumina to form an orange lake, and if melted with caustic potash between 135° and 150° C., it forms an isomer of purpurin.

The other yields a soda salt sparingly soluble and readily crystallisable; it is insoluble in cold baryta water, does not combine with gelatinous alumina, and if melted with potassa at the same temperature, it does not give rise to a colouring matter; a little only is formed at a higher temperature, with the destruction of a large portion of the substance. This second body can be obtained in the form of fine silky needles, which in bulk present the yellow colour of chromate of lead, and recalls the aspect of chrysophonic acid.—*Comptes Rendus*, June 12, 1876.

ANTHRAFLAVIC ACID, $C^{14}H^8O^4$. An acid, isomeric with alizarin, obtained as a by-product in the preparation of the latter by melting disulphanthraquinonic acid with potash. See WATTS's *Dictionary of Chemistry*.

ANTHRAPURPURIN. Mr. W. H. PERKIN, in the *Journal of the Chemical Society* for June, 1876, gives a paper 'On the Formation of *Anthrapurpurin*,' in which he discusses the researches of GRAEBE and LIEBERMANN, and of SCHUNCK and H. ROEMER, and then gives a process for the direct formation from disulpho-acid of anthraquinon. The chemical reactions given will be found in WATTS's *Dictionary of Chemistry*. Mr. PERKIN states that in the formation of anthraquinon from disulph-anthraquinonic acid there are 3 successive reactions:—

1. The formation of sulphoxyanthraquinonic acid;
2. The formation of isoanthraflavic acid; and
3. The formation of *Anthrapurpurin* by the oxidation of the latter substance thus:—

$$\underset{\text{Potassic isoanthraflavate.}}{C^{14}H^6O^2\begin{Bmatrix}(OK)\\(OK)\end{Bmatrix}} + KOH = \underset{\text{Potassic anthrapurpurate.}}{C^{14}H^5O^2\begin{Bmatrix}(OK)\\(OK)\\(OK)\end{Bmatrix}} + H^2$$

isoanthraflavic acid standing to anthrapurpurin as oxyanthraquinon does to alizarin. Anthrapurpurin, when heated with ammonia, produces an amide derivative. This, when dissolved in boiling alcohol and treated with nitrous acid, yielded a product which, when sublimed and crystallised from acetic acid, was obtained in golden needles, and yielded a colouring matter when heated with alkali, dyeing mordants of the same colour as anthrapurpurin.

ANTHRAQUINON. LUCK's process for preparing this is as follows:—One gram of anthracen is dissolved at a boiling heat in 45 c.c. of glacial acetic acid in a small flask. It is filtered, if necessary, at a boil through a small filter, and a solution

of 10 grams of chromic acid in 5 c.c. of water and 5 c.c. glacial acetic acid is gradually added in small portions, so that the liquid may continue to boil gently. This is continued until a distinct and permanent greenish yellow colour appears, or till, after prolonged boiling, a drop of the liquid placed upon a clean silver coin produces in a few minutes a reddish spot of chromate of silver. The liquid is then allowed to cool, gradually diluted with 150 c.c. of water filtered after a few hours, and the anthraquinon on the filter is washed with water, then with hot, very dilute potash lye, then again with water, and dried at 100° C.

For the industrial preparation of anthraquinon, anthracen is employed, which, after a more or less perfect purification, is treated with chromic acid, nitric acid, &c.

For the purification of crude anthraquinon, it has been recommended to boil it with dilute soda lye and zinc dust, to filter hot, and to precipitate anthraquinon from the filtrate by blowing in air. Anthraquinon purified in this manner requires to be treated with sulphuric acid to make it fit for the subsequent operations.

Anthraquinon sublimes in beautiful golden yellow needles; but, on the large scale, it is obtained in fine dark gold coloured columns, several inches in length. The colour varies greatly, depending probably on the size of the crystals.

ANTHRAQUINON, RED. AUERBACH obtains this from alizarin paste. If this is evaporated to dryness and sublimed, the sublimate is not perfectly soluble in hydrate of soda, but orange red needles are left behind. With zinc powder and hydrate of soda they give the characterising red colour of anthraquinon.

Anthraquinon, $C^{14}H^8O^2$. The boiling point of this compound is above that of mercury. Its vapour density is 7·33.—GRAEBE, *Deut. Chem. Ges. Ber.* v. 15.

M. F. GOPPELSROEDER says (*Comptes Rendus*): '*Anthraquinon* has attracted my attention. I sought first to transform it by electrolysis at a low temperature into alizarin, and the latter into purpurin, but without success. I commenced then a new series of experiments, operating at a high temperature. Meeting anew with great difficulties, I obtained, however, a result which encourages me to continue my studies. I observed that on operating with caution a part of the anthraquinon is transformed into alizarin. This transformation takes place on introducing into a very concentrated solution of caustic potash anthraquinon reduced to a very fine powder, passing the galvanic current, and heating almost to the melting point of potash. The mass is coloured at first red and then violet by the formation of alizarate of potassium. But this colouration is rapidly replaced by a new red colouration, which soon changes to a yellowish brown, and even to a deep brown, and consequently we obtain a violet product mixed with unchanged anthraquinon and with brown electrolytic products. If we continue to heat it, the mass becomes more and more clear and finally white. If at the moment when the last red colouration presents itself, we reverse the current, the mass again becomes violet, then red and yellowish, because without doubt anthraquinon and even anthracen are formed again. I may say, moreover, in a general manner that, if we do not go too far with decompositions, we may, by reversing the poles of the battery, regenerate at the new negative pole the modified bodies, and reproduce at the new positive pole the transformations that were previously produced at the opposite electrode. In the electrolysis described by the derivatives of aniline, phenol and naphthalium the positive pole plays the principal part. In the electrolysis of anthraquinon it is at the negative pole that the violet colouration commences and remains most intense during the whole of the operation. All the experiments of which I have just spoken depend on the decomposition of water or an alkaline derivative by the current. It is the electrolytic oxygen which acts in dehydrogenising, or in other cases it is the oxyhydryl of the potassium or of the sodium which is substituted for the hydrogen of the chromogen.

'Up to the present time I have turned my attention especially to the principal products, without losing sight of the secondary products, the study of which is necessary to arrive at a clear idea of the metamorphoses which take place. It is also necessary to observe the gaseous products. The action of the current on melted organic bodies, proceeding as we do in mineral chemistry, will present especially great difficulties, whether because heat alone decomposes them, or because the electric conductibility is too weak; but the study of these actions ought not to be neglected. We ought to try also to arrive at the simultaneous decomposition of other bodies added to the electrolyte, to arrive at substitution products of the chromogen or of its electrolytic product. We shall thus arrive at substitutions by alcoholic radicals and by the phenyl series, just as we succeed by the aid of nitric acid or nitrates in producing at the positive pole nitro-derivatives, and at the negative pole nitroamido-, amido-, and even azo-derivatives. The chemistry of colouring matters will find in the researches of which I have spoken a field so much the more fertile as the oxidations and the dehydrogenisations play the most important part in the production of colour.'

ANTHROKIRRIN, a colouring matter derived from the flowers of the toad flax (*Linaria cymbalaria*), sometimes called the "mother of thousands."

The flowers are treated with hot alcohol, and the infusion evaporated to dryness, the dry residue exhausted with hot water, to remove the sugar and gum. The insoluble portion is again treated with alcohol, the solution filtered and evaporated, and the residue dissolved in ether. When the ethereal solution is evaporated, the colouring matter is deposited in yellow needles, which can be sublimed unchanged.

With alum *anthrokirrin* gives yellow lakes.

The oil of the toad flax, when mixed with milk, is said to poison flies.

ANTIMONY, *in Arkansas*. Among samples of ores forwarded to Professor C. P. Williams of Rolla, Missouri, in January last, was a specimen which was at once recognised as stibnite, and on notification, other specimens of the same from Sevier County were forwarded. The first specimen of the several received contained 11·51 per cent. of gangue, 57·69 per cent. antimony, 4·57 of bismuth, with small amounts of arsenic and iron. The latest result from a portion of another hand specimen is appended in full, with duplicate estimations of the arsenic, bismuth, and gangue. The analyses were all conducted by Mr. C. R. Winters, under Professor Williams's direction; and in the case of those given below the ore was separated as closely as possible from the gangue before analysis. The results are for the mineral freed from hygroscopic moisture, and are as follow:—

	I.	II.	Mean
Sulphur	28·518	—	28·518
Antimony	68·576	—	68·576
Arsenic	·547	·474	·497
Bismuth	·621	·408	·590
Iron	·762	—	·762
Gangue	·944	·948	·946
	99·968		99·889

This result indicates that the ore is stibnite.

With varying, but always small, amounts of the sulphides of antimony replaced by the isomorphous sulphides, orpiment and bismuthinite, the mineralogical composition of the above specimen would be as follows:—

Stibnite	95·417	per cent.
Orpiment	·815	,,
Bismuthinite	·626	,,
Pyrite	1·632	,,
Quartz	·946	,,
	99·436	,,

The mineral is interesting from the association of bismuth with the antimony, and from the fact of adding another locality of antimony ores to the few now known in the United States.

In Canada.—In 1863 a deposit—containing native antimony, antimony glance, with small quantities of *Senarmontite*, *Valentinite*, and *Kermesite* (red oxysulphide)—was found in the township of South Ham, in the magnesian rocks of the Quebec group. The Lake George Mining Company are working grey sulphide of antimony at Prince William.

The occurrence of stibnite or grey sulphide of antimony at Prince William seems to have been known for a number of years without attracting much attention until about the year 1862, when fresh discoveries having been made indicating a considerable body of ore, several companies were formed with a view to its development. Through their explorations the mineral was found to be more or less abundantly spread over an area of several square miles, occurring chiefly in veins of white quartz or of quartz and calc spar, intersecting hard clay slates and sandstones of undetermined age. These veins vary in thickness from a few inches to 6 feet, the ore being irregularly distributed through the quartz in strings or veinlets, sometimes attaining a thickness of from 12 to 15 inches. A large portion of that hitherto raised has been obtained within a short distance of the surface by means of trenches dug on the course of the lodes, but several shafts have also been sunk to a depth of over 100 ft. In connection with these, the Lake George Mining Company have erected extensive works and machinery, embracing an 80-horse power engine, a 30-horse power air-compressor engine, a Burleigh steam drill, Blake's crusher, rollers, jiggers, &c., as well as furnaces for desulphurisation and smelting. These, when in full operation, yield 15 tons of metal about every six weeks, the charges (of 500 cwt.) yielding from

45 to 55 per cent. of regulus. The materials employed in smelting are charcoal, soda or salt-cake, and resin. The value of the metal on the ground is 12 to 14 cents per pound. It is partly exported in cakes or ingots to the United States, and partly employed on the ground in the manufacture of Babbit metal (containing 15 to 20 per cent. of antimony with lead and tin, or in the better qualities with lead, copper, and tin), valued at from 20 to 50 cents per pound.

In New South Wales.—The compiler of the *Mines and Mineral Statistics of New South Wales* says:—'But little attention appears to have been paid to the extraction of this mineral (antimony), though it has been discovered in various parts of the colony in such quantities as should, under favourable circumstances, render the working of it a profitable employment. As the mineral resources of the colony come to be better known and appreciated, there is no doubt antimony will be raised in larger quantities, and will form an important item in our returns.'

The Produce of the Colony in	tons	cwt.	Value £
1871	31	0	460
1872	0	13	5
1873	27	12	210
1874	12	15	122
Total	72	0	897

The sulphide of antimony has of late years been found in several parts of this colony.

This ore is met with in the massive state in mineral veins, and occasionally in rolled masses; crystals appear to be rare.

It occurs on the Clarence and Paterson Rivers, the mineral occurring in masses of large size, and showing broad, well defined, striated cleavage plains, portions of the surface usually being incrusted with a yellow coating of cervantite, an oxide of antimony $= SbO^4$.

It is found associated in many parts of New England with tinstone, molybdenite, wolfram, and other minerals.

Localities.—Tenterfield, Armidale, Gresford, Rylstone, Rocky River, Grafton, Macleay and Hastings Rivers, near Mt.-Mitchell, Booroloog, Gara, Drake, Nundle Gold Field, Solferino, Wallerawang, Gundagai, Shoalhaven River, Eden, Twofold Bay.

Antimony Mines in Queensland.—Amongst the many valuable mineral properties that exist in Queensland are the antimony mines of Neardie. They are situated 40 miles by road from the town of Maryborough and 23 miles from Tiaro, or head of navigation of the Mary River. The surveyed railway line to Gympie passes the mines within 12 miles. There are five 80-acre and two 20-acre blocks that have been proved; but out of the seven blocks, consisting of in all 440 acres, only one block is being worked by a small company. Some hundreds of tons of ore, averaging over 60 per cent., have been raised and shipped at Brisbane and Melbourne. Assays have been made at Gympie, Maryborough, Brisbane, Sydney, Melbourne, Ballarat, and London—all agreeing that the ore is of the purest quality, being free from arsenic, lead, or other deleterious ingredient. One large sample of star regulus from this ore was manufactured at the Bulimba Smelting Works, near Brisbane, and was pronounced to be of high quality. The known lodes are three, besides many leaders.

The return drays from Gympie at present carry the ore to Maryborough, under contract, for 1*l.* 17*s.* 6*d.* per ton. Traces of gold was the result of the London assay; and gold, both in quartz and alluvial, is found extending from these mines to Gympie and beyond it.

Stibnite is found at Carrick, containing from 50 to 54 per cent. of antimony. It is also found at Miller's Flat, and near Arrow Town.

Antimony may be deposited on copper or brass by using a bath of the double chloride of antimony and ammonium, the solution being slightly acidulated with hydrochloric acid.

APATITE, or *Phosphate of Lime.* (Vol. i. p. 201.) Apatite in both beds and veins is very common in the Laurentian rocks of Canada, and has been mined on a small scale for some years. It is generally found in pyroxenic or garnetiferous gneiss, or in crystalline limestone, and deposits several feet in thickness, and almost entirely free from foreign minerals, are of frequent occurrence. When in the form of scattered crystals in limestone it is of little economic value, on account of the difficulty of separating it from its matrix. The best known deposits are in Ontario, in the townships of North and South Burgess and North Elmsley; but important localities have

also been discovered in Buckingham and Portland townships, Quebec. As yet, underground mining has been attempted in only a few instances, the apatite being chiefly derived from shallow pits and trenches. The deepest mine is on the tenth lot of the sixth concession of North Burgess, where two shafts were sunk in 1873 to depths of 135 ft. and 70 ft. respectively, on veins of sea-green apatite from 6 in. to 6 ft. in thickness.

The apatite, as it comes from the mines, is said to contain an average of about 80 per cent. of phosphate of lime. It is first broken by a small BLAKE'S rock-breaker, then crushed between iron rollers, and, after passing through a series of sieves to free it from mica, ground between ordinary millstones. The ground mineral is then mixed in an agitator with an equal weight of sulphuric acid of 60° Baumé. From the agitator it is placed in a car, which in turn tilts it into a series of bins, where it soon solidifies into white honey-combed masses, containing, it is said, as high as 20 per cent. of soluble phosphoric acid. The superphosphate is then broken or ground up in a CARR'S disintegrator, and put up in barrels for shipment.

APHROSIDERITE. A ferruginous Ripidolite (silica, alumina, magnesia and protoxyde of iron. See RIPIDOLITE), occurring in fine scaly grains in the Duchy of Nassau. The iron in the mineral exists as silicate. From analyses the formula $5(2RO,SiO^2) + 5(2R^2O^3SiO^2) + 8H^2O$ is deduced, where R = ferrous oxide and magnesia R^2O^3 = ferric oxide and alumina.—F. NIES, *Chem. Centr.*, 1875.

APPARATIN. A colourless transparent substance, obtained from starch by treatment with caustic alkalies, is so called. Seventy-six parts of water, 16 parts of potato starch, and 8 parts of potash or soda solution of 25°, turn to a thick jelly. The longer it is beaten up the better it becomes. If dried in thin plates, it is of horny consistence, but less brittle than horn. It may be used for stiffening cloth of all sorts. It is nearly insoluble after drying, and is not removed by two or three washings in warm water.—H. GUERARD, *Dingl. polyt. J.*, ccxvi.

APOCYNACEÆ. A natural order of corolliflоral exogens. One of the sources of *Caoutchouc*. Most of the species inhabit the tropical countries, but some few belong to the temperate regions, among which are the *Vinca*, or the common periwinkle; the *Nerium* or oleander. Many of the species are poisonous; some are used in medicine as emetics and cathartics; and some few yield edible fruits. The poisonous and medicinal qualities of the plants reside in the milky juices, which the stem, when wounded, yields in large quantities. Many of the plants of this order supply caoutchouc, the principal ones being *Urceola elastica*, *Vahea gummifera* and *Willughbeia edulis*. The *Wrightia tinctoria* yields an indigo colour dye; the seed pods of the *Apocynum caudatum* and *A. villosum* produce a cottony down, which is called by the French *Delawad*, and is in great request for making quilts, stuffing chairs, &c. The *Apocynum androsæmifolium* is the *Fly-trap* of North America, much cultivated in this country as an object of curiosity, as some affirm that it catches and digests flies and insects as an animal digests its food; there are five scales or hairs in the throat of the flower of this fly-trap which secrete a sweet liquid; this attracts the honey loving insects, and immediately their scales are touched their extreme irritability (the cause of which has not been yet determined) causes them to bend towards the centre of the flower, and retain the insect prisoner. The *Tabernæmontana*, the hya-hya or cow tree of Demarara, yields a juice which is used as milk by the inhabitants. See CAOUTCHOUC, BURMAH.

APOCYNUM. A genus of *Apocynaceæ*.

ARACHIS HYPOGÆA. The ground-nut of Angola is of considerable importance. Many thousand tons of this little nut are grown on the west coast of Africa, large quantities being exported to Europe—principally to France—from which oil is expressed. The native name for this nut is 'mpinda' or 'ginguba,' and it is cultivated in great abundance at a few miles inland from the coast. It requires a rich soil for its cultivation, and is chiefly grown in the bottoms of valleys or in the vicinity of rivers or marshes. The plant grows from one to two feet high, with a leaf very much like a finely grown clover. The bright yellow pea-like flowers are borne on long slender stalks; these, after flowering, curl down, and force the pod into the ground, where it ripens beneath the soil. Its cultivation is a very simple affair. The ground being cleared, the weeds and grass are allowed to dry, and then burnt. The ground is then lightly digged a few inches deep by women with their little hoes—their only implement of agriculture, and the seeds dropped into the ground and covered up. The sowing takes place in October and November, at the beginning of the rainy season, and the first crop of nuts for eating green is ready about April; but they are not ripe for nine months after sowing, or about July or August, when they are first brought down to the coast for sale. A large plantation of ground-nuts is a very beautiful sight: a rich expanse of the most luxuriant foliage of the brightest green, every leaf studded with diamond-like drops glittering in the early sun. These

nuts are used largely as food by the natives, especially in the country from Ambriz to the river Congo. A considerable quantity of oil used to be prepared by the natives from this nut by the most rudimentary process it is possible to imagine. The nuts are first pounded into a mass in a wooden mortar, a handful of this is then taken into the palms of the hand, and an attendant pours a small quantity of hot water on it, and on squeezing the hands tightly together the oil and water run out. Since the great demand for, and trade in, the ground-nut, but little oil is prepared by the natives, as they find it more advantageous to sell the nuts than to extract the oil.—*Angola and the River Congo*, by Joachim John Monteiro, 1875.

ARBALIST. (*Arcus* and *balista*, Lat.) A crossbow. Applied rather absurdly to a machine for granulating auriferous quartz, by E. A. Pitton, in the specifications of his patent in the Patent Office, Victoria.

ARCHIL. Used for colouring wines. For its mode of detection, see Wines.

Extract and dough. The lichens are macerated for a quarter of an hour in water, to which a small quantity of potash is added. This is heated in closed vessels from 100° to 120° C. by means of high pressure steam. The acids are thus converted completely into orcin. The clear liquid is separated from the insoluble woody mass and concentrated by evaporation. This concentrated solution is then treated with ammonia, and oxygen introduced. Thus the formation of orcin rapidly takes place.

To obtain archil dough a quantity of extracted lichens is added to the above concentrated solution, treated with ammonia until the mixture assumes a thick pasty form, and oxygen is introduced. An agitator is used to ensure the action of oxygen on all parts of the dough.—*Dingl. poly. J.*, ccxx. 460.

ARSENIC. *Manufacture of, from the waste of aniline colour works.* When colours are produced from aniline by the action of arsenic acid, there is a by-product obtained which consists of arsenious acid and lime, and it also contains carbonaceous matters derived from the aniline. Mr. E. A. Parnell, of Swansea, has recently patented a method of extracting the arsenic. When the arsenical by-product is calcined at a moderate heat, a portion of its arsenic, amounting to about one-third of the total quantity present, is disengaged and volatilised as metallic arsenic. The remainder of the arsenic is contained in the residue in the state of arseniate of lime, from which heat alone is insufficient for the elimination of the arsenic. Under Mr. Parnell's invention the decomposition of the arsenical lime compound is effected by the addition of a silicious material in conjunction with a carbonaceous or other deoxidising material. At a moderate red heat the lime then unites with silica, thereby producing silicate of lime, and the arsenic is disengaged in the metallic state, and capable of being condensed and collected in the usual way in a condenser or long flue. The presence of a deoxidising agent in conjunction with silica is essential to effect a rapid decomposition of the arsenical lime compound. The process may be conducted successfully in a variety of ways: for example, the arsenical by-product may be mixed in a direct manner without previous calcination with the silicious material; or it may be first calcined, and resulting arseniate of lime mixed with silica and a deoxidising substance. In the raw or uncalcined state the said by-product often contains sufficient carbonaceous matter to render the further addition of reducing material unnecessary. Mr. Parnell does not confine himself to the use of carbonaceous material as a reducing agent, as, arsenical pyrites or mundic may likewise be employed with good results. The arsenic contained therein, as well as that in the lime compound, is disengaged, and a mixture of silicate of lime and silicate of oxide of iron remains behind.

Of the materials mentioned the proportions which he prefers to employ vary under different circumstances. With silicious sand and coal he proceeds thus:—To a quantity of the uncalcined arsenical by-product, containing four parts of lime, he adds five parts of fine silicious sand, mixes the same immediately, and afterwards adds two parts of small coal.

For the purpose of heating the mixture of the uncalcined arsenical by-product with sand, Mr. Parnell prefers to employ a revolving cylinder similar to Oxland and Hocking's revolving calciner for ores and minerals, the same being slightly inclined with a fireplace at one end. See Calciner. The raw mixture is allowed to enter continuously in a dry state into the cylinder at the end farthest from the fire, and the silicate of lime to flow out in a pulverulent state from the end next the fire. If the raw materials have been well mixed, it is not necessary that the heat be raised so high as to cause incipient fusion of the silicate of lime. The most convenient source of heat, whether the furnace be a reverberatory furnace or a revolving cylinder, is a gas producer similar to that employed in connection with the Siemens' regenerative furnace. By means of the gas producer sufficient heat is obtained without exposing the mixture to excess of air. In order to oxidise the volatilised metallic arsenic and obtain arsenious

acid, air is admitted through openings in the condensing chamber when it adjoins the revolving cylinder.

Another method which Mr. Parnell also employs for conducting his process is included in the patent. Having calcined the said arsenical by-product, he mixes the resulting arseniate of lime with moist clay, sand, and small coal, and forms the mixture into balls or pellets, which when dry he calcines in an ordinary kiln, heated by a subjacent reducing fire. For this mode of conducting the process he employs the following mixture:—Calcined arseniate of lime, 4 parts; dry sand, 2 parts; small coal, 1 part; and moist clay sufficient to contain, if dry, 1 part. When his object is to obtain metallic arsenic from either of the mixtures described, he carefully avoids the admission of an excess of air, not only in the furnace, but also in the condensing chamber. When his object is to obtain arsenious acid, he allows air for the combustion of the arsenic to be sucked in at the entrance into the condenser, or under the bed of the reverberatory furnace.

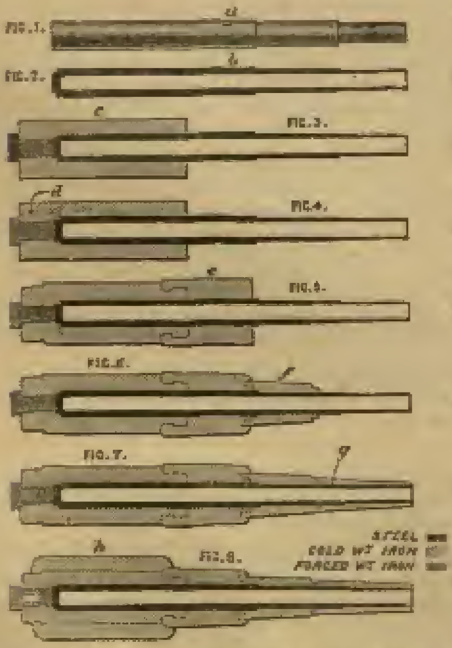
Arsenic, in Prussia. See Mineral Products. *Prussia.*

ARTILLERY. (*Artillerie*, Fr.; *Die Artillerie*, Ger.) (Vol. i. p. 228.) Major Maitland, R.A., Assistant Superintendent of the Royal Gun Factories, gives in the *Royal Artillery Institution Proceedings* an account of the 80-ton gun, from which we extract much of the following.

The preparation of this vast piece of ordnance may be divided into two parts: one being the actual making of the gun, the other the enlargement of lathes, the raising of roofs, the strengthening of cranes, bridges, and railways, with many other alterations which will readily suggest themselves. Besides these important points, there remain to be taken into account the projectiles and the carriage.

Those familiar with the heavy ordnance of our service will have noticed that of late years the thin coils, and many-stepped outline, belonging to the earlier models of the Armstrong system have gradually given place to the bolder curves and massive coils of what is known as the 'Fraser' construction. The change has resulted in greater strength, endurance, and economy; and, these qualities, as far as yet tested, have been amply realised in the 80-ton gun.

2206



1. Steel block as received from contractor.

2. The tube bored through *b*.

3. *c*, breech piece shrunk on.

4. *d*, cascable screwed in.

5. *e*, 1 *B* coil shrunk on.

6. *f*, 2 *B* coil shrunk on.

7. *g*, *B* tube shrunk on. (In this stage the gun is finished, bored, and rifled.)

8. *h*, *C* coil shrunk on. (The gun is then vented.)

The interior of the gun is formed by a solid-ended steel tube, (*a*) *fig.* 2206. The manufacture of these tubes is, to a certain extent, a speciality. That for the 80-ton gun weighed 16½ tons, and no flaws could be detected in it. The material used is entirely

that known as crucible steel, being melted in about 240 small crucibles, whose contents are run into a large mould. The process is very expensive and eminently unscientific—having, indeed, nothing to recommend it but its success.

It is not requisite to describe minutely the details of the manufacture of our ordnance, as that has been already done in the previous article; we will merely indicate the successive processes of building up the 80-ton gun. Over the rear end of the steel tube is shrunk a very powerful coil, called the breech-piece (3, *fig.* 2200). This is made of a single bar, 12 in. thick from inside to outside, hammered, rolled, and coiled, forming a cardinal point in the mode of construction. The cascable is next screwed in (4), so as to abut firmly against the solid end of the tube, and the *B* coils are then shrunk on into their places (5, 6, 7). The ponderous *C* coil, carrying the trunnions, comes last (8), and is in truth a marvellous piece of forging. It was made of two coils—one outside the other—and was 18 in. thick. These coils were welded together under the 40-ton hammer. It should be stated that, in order to obtain greater certainty of soundness and ease of manipulation, both the breech-piece and the *C* coil were made in two pieces, which were welded together, end to end; care being taken that the weld of the breech-piece was not inconveniently near that of the *C* coil.

The sketches appended give a clear idea of the successive processes, and the Table A shows the weights of the forgings, both in the rough state and after finishing. It will be noticed that the total amount of iron used is twice that of the gun. This waste is due to the necessity for turning off the surfaces and ends of the coils, so as to obtain a fine clear metal, free from flaws. The metal turned off is, of course, used again.

TABLE A.—*Detail of Weight of Material for 80-ton M.L.R. Gun.*

Name of piece	Size of bars	Length of bars	Weight of bars tons	cwt.	qr.	Weight of iron used in gun tons	cwt.	qr.	Finished weight of parts of gun tons	cwt.	qr.
A tube (steel) .	...	...		...		16	10	0	7	13	0
Breech-piece .	$12 \times 10 \times 9\frac{1}{2}$	60	7	10	0	29	8	0	17	10	3
	$11 \times 10 \times 8\frac{1}{2}$	160	21	18	0						
Cascable . .	...	...		...		1	7	0	0	19	0
1 B coil . .	$8\frac{1}{2} \times 6\frac{1}{2} \times 5\frac{3}{4}$	80	6	9	0	27	6	0	13	8	0
	"	80	6	9	0						
	"	192	14	8	0						
2 B coil . .	$8\frac{1}{4} \times 6\frac{1}{2} \times 6\frac{1}{2}$	30	2	5	0	6	5	0	4	3	0
	$7\frac{1}{2} \times 6\frac{1}{2} \times 6\frac{1}{2}$	32	2	4	0						
	$7 \times 6 \times 6$	31	1	16	0						
B tube . .	$7\frac{1}{2} \times 6 \times 5\frac{3}{4}$	60	4	2	2	8	1	1	3	8	0
	$7 \times 6 \times 5$	40	2	6	2						
	$6 \times 4\frac{1}{2} \times 4\frac{1}{2}$	40	1	12	1						
Trunnion . .	...	...		...		18	0	0		...	
C coil . .	$8\frac{1}{2} \times 6\frac{1}{2} \times 5\frac{3}{4}$	173	12	19	2	57	19	0	34	5	
	$8\frac{1}{2} \times 6\frac{1}{2} \times 5\frac{3}{4}$	173	12	19	2						
	$9\frac{1}{2} \times 5\frac{1}{2} \times 7$	300	32	0	0						
						164	16	1	81	6	0

This now well-known principle of shrinking on the successive layers affords very great additional strength to the system, since by its aid the strain of the discharge is transmitted to the very exterior of the gun, which thus adds its quota to the resistance. The efficacy of the shrinking process is well shown by the measurements taken of the interior of the gun during manufacture. Thus the shrinkage of the powerful coiled breech-piece caused the bore to contract ·020 in., and the compression of the massive outer coil carrying the trunnions was so great that it was transmitted through the breech-piece, and caused a further contraction of ·023 in. in the bore.

The shrinkage was so adjusted that the maximum contraction (·043 in.) took place at a point 32 in. from the end of the bore, and gradually died away in each direction towards breech and muzzle. Thus the pressure of the gas—which is greatest in the powder chamber, and for a short distance in front of the base of the shot—was directly transmitted to the outer or *C* coil, the great strength and thickness of which form an important point in the system. It often happens, on firing a new gun, that the shock of discharge permits the atoms of the material to shake themselves, as it were, and to

settle down more comfortably. This sometimes results in the shrinkage of the outer coils taking increased effect on the steel tube; but more usually the steel tube fits its exterior better to the interior of the coils, or perhaps slightly compresses their nearest particles, so that a small expansion ensues. It will be convenient here to draw attention to the Table B of measurements. The figures (*fig.* 2206) represent the diameter of the bore at short intervals taken horizontally, before and after the

TABLE B.—*Showing Horizontal Measurements of the Bore of the 80-ton Gun.*

Inches from muzzle	Before shrinking on outer coil	After shrinking on outer coil	After firing 21 rounds	
	in.	in.	in.	in.
190	14·498	14·498	14·498	...
196	14·498	14·498	14·496	Contraction.
202	14·498	14·495	14·494	·001
208	14·498	14·494	14·493	·001
214	14·499	14·495	14·494	·001
220	14·499	14·494	14·492	·002
226	14·499	14·490	14·490	*nil.*
				Expansion.
232	14·500	14·488	14·489	·001
238	14·500	14·482	14·484	·002
244	14·499	14·480	14·481	·001
250	14·499	14·476	14·480	·004
256	14·499	14·476	14·478	·002
262	14·500	14·480	14·481	·001
268	14·500	14·483	14·484	·001
274	14·495	14·481	14·481	*nil.*

NOTE.—*The vertical measurements are almost identical with those given above.*

shrinking on of the outer or *C* coil. To the compression given must be added that of the breech-piece, which was put on before the interior of the tube was 'finish-bored.' This compression reached its maximum of ·02 in. at from 240 in. to 270 in. from the muzzle. The gun, after firing 21 rounds, exhibited, as shown by the table, a slight contraction in front of 226 in. from the muzzle, and a slight expansion in rear of this point, both being so small that the bore may be said to be practically unaltered; and thus the outer coils retain undiminished their power of promptly taking up the strain imposed on the tube.

It may here be remarked that the object of the tube is not so much to afford transverse strength as to furnish a good and impenetrable surface. In fact, the Woolwich guns are constructed to stand with safety, even if the tube should split.

It was thought desirable, in order to obtain as much information as possible, to bore the 80-ton gun to 14½ in. in the first instance, and to increase the calibre by half an inch at a time, till the full size of 16 in. should be reached. It is anticipated that, by carrying on experiments at each stage, much valuable knowledge relating to the behaviour of powder and the manufacture of heavy projectiles will be acquired.

The gun was ready, in its 14½ in. calibre, for firing early in September 1875, having taken just eighteen months to complete. Of this time, several months were occupied by the necessity for enlarging various parts of the plant in the Royal Gun Factories. The unprecedented size of the bars forming the coils entailed much heavy forge work, and the rolling mill then in use was not powerful enough to turn out such sections of iron. The coiling furnace required alteration; the roof of the tempering house, where the steel tube is toughened in oil, had to be raised; the hydraulic crane had to be patched up to take weights beyond its safe strength; a lathe and boring machine of immense length were obvious necessities; the railways, wherever the gun was intended to travel, required strengthening; the bridge over the canal was almost reconstructed.

After the description given in the former volume of the manufacture of the Woolwich Infant by Captain NOBLE, it appears unnecessary to enlarge upon the merits of the experiments which have been made in the construction of giant pieces of artillery. It is not possible in a work of this character to enter into the whole question at issue; we therefore consider a general description to be all that is necessary.

ASBESTOS POWDER. Asbestos powder, made into a thick paste with liquid silicate of soda, is used with great advantage for making joints, fitting taps, connect-

ing pipes and filling cracks in retorts. This composition hardens very quickly, will stand any amount of heat, and prevents the escape of acid vapours; hence it is very serviceable in the manufacture of acids and other corrosive products.

Mr. JOHN CASTHELAZ says that he has used asbestos powder as a lute for making joints, fitting taps and the like for about 20 years with constant success. The powdered asbestos is made into a thick paste with liquid silicate of soda, and applied to connecting pipes or to cracks in retorts. It is said to be of great service in the manufacture of nitric acid, sulphuric acid, or other corrosive products. It can be employed in a very easy way; it hardens very quickly, stands almost any heat, and prevents the escape of acid vapours.—*Chemical News.*

ASCLEPIAS. The genus of herbaceous plants with a milky juice. Some of the species furnish excellent fibre, which is woven into muslins, and, in some parts of India, is made into paper. See TEXTILE MATERIALS.

ASPHALT. (Vol. i. p. 257.) Is now largely used in the laying of wood pavement.

Imports into England.

	1874		1875	
	Tons	Value	Tons	Value
From Germany . . .	2,116	£8,271	4,156	£13,268
„ Holland . . .	2,849	10,174	4,087	15,877
„ France . . .	1,628	6,677	1,849	5,477
„ British West Indies .	3,595	12,628	3,840	12,534
„ other Countries . .	1,188	2,555	641	1,618
Total	11,376	40,305	14,213	48,774

ASPHALT, &c. *in Prussia.* See MINERAL PRODUCTIONS. *Prussia.*

ASSAY COPPER. See COPPER ASSAY.

ATMOSPHERIC PRESSURE *used for raising coals.* See COALS *raised by atmospheric pressure.* The substance of a paper translated from the French by Mr. THEODORE WOOD BUNNING, and published in the *Transactions of the North of England Institute of Mining and Mechanical Engineers*, December 1875.

AUGITE. (Vol. i. p. 273.) See LAVA.

AURANTIA. GNEHM of Zürich says this beautiful orange dye is the ammonia salt of an acid, which he has described under the name of *Dipicrylamin.* The colour was first made by BINDSCHEDLER and BUSCH of Basle, about the end of 1874. This firm, however, has ceased manufacturing the colour, because the salts of the acid in question exert a powerfully irritating action upon the skin, and occasion eruptions resembling those produced by the application of croton oil. This action, however, appears to depend on idiosyncrasy. C. A. MARTIUS remarks that the aurantia prepared by him does not produce this effect, and that the experiments undertaken by SALKOWSKY in the Physiological Institute of the University of Berlin prove the colour to be innocuous. The injurious effects of the Swiss samples must therefore be traced to an impurity. Aurantia, as appears from its composition, is violently explosive, and should be kept slightly moist with glycerin.—REIMANN'S *Färber Zeitung*, No. 38, 1876.

AURANTIN. Dr. DE VRIJ found in the flowers of *Citrus decumana* a glucoside, which he believed to be *Hesperedin*; but it is a different body, and may be called *Aurantin.* The small yellow crystals consist of $C^{23}H^{26}O^{12}+4H^2O$.—E. HOFFMANN, *Deut. Chem. Ges. Ber.* ix.

AURIFEROUS PYRITES. *Treatment by Bromine.* See PYRITES, AURIFEROUS, *Refined by Bromine.*

AURIN, another name for *Rosolic Acid* and *Yellow Corallin.* To obtain this substance in a pure state, commercial rosolic acid is dissolved in boiling alcohol and alcohol saturated with ammonia is added. A crystalline compound of aurin and ammonia, almost insoluble in alcohol, separates out, the impurities remaining in the solution. The deposit is washed in alcohol and exposed to air, when the ammonia vaporised and pure aurin remains.

AURIN ORANGE. To print this colour 6 ozs. of the aurine solution is mixed with a gallon of thickening, made of 7 pints of water, 1 pint of ammonia, and 2 lb. of leiocome, and well stirred until perfectly dissolved.

AUTOTYPE. (Vol. i. p. 277.) For the recent improvements in this and other processes of photographic printing, see PHOTOGRAPHIC PRINTING.

AUTUNITE. An ore of uranium, found at Autun and St.-Yrieux, not far from

Limoges, in France. Analyses by Berzelius and Werther give the following composition:—

Phosphoric acid	15·20	14·00
Oxide of uranium	61·73	63·28
Lime	5·88	5·86
Magnesia and protoxide of manganese	0·20	—
Barytes	1·57	1·03
Oxide of tin	0·06	—
Water	15·48	14·30

See Church on the Composition of Autunite, *Journal of the Chemical Society*, 1875.

B

BABBIT METAL. An alloy of antimony. It contains from 15 to 20 per cent. of antimony with lead or tin. The better qualities are said to give 20 per cent. of antimony, with lead, copper, and tin. It is sold at about two shillings a pound.

BADIGEON. A mixture used for stopping holes in stone or wood work. That used for stone is prepared with plaster-of-Paris and powdered freestone; that for wood work, with fine sawdust and strong glue—sometimes putty only is used.

BALATA. A kind of caoutchouc obtained from the milky juice of the Bully tree of Guiana, the *Sapota Mülleri*, a species of Mimusops, which grows from one hundred to one hundred and twenty feet high, with a trunk six feet in diameter. It is also called the Bullet tree, by reason of its round seeds, which are commonly eaten by the natives.

BALISIER (French), derived from a Spanish word signifying 'cover.' In Brazil the leaves of the Canna are used for packing purposes and called by this name.

BALOGHIE. One of the Spurgewort family, which grows in Norfolk Island. When an incision is made through the bark a blood-red sap oozes from the trunk, which is used by the natives for marking bags, blankets, &c.

BAMBOO. Said to be grown in Sunderland by a gentleman; who reports a produce equal to 40 tons per acre, of which 60 per cent., is good paper-making fibre.

BANCOUL NUTS. This nut is obtained from one of the *Euphorbiaceæ*, the *Aleurites triloba*, a native of Ceylon, Cochin China, and several of the islands of the Pacific, commonly called the Candleberry tree.

It yields an oil which is purgative, and, even without refining it is said to burn better than colza oil. It is said also to preserve ships' bottoms. The great obstacle to the importation of the nut into Europe is the hardness and large percentage of the endocarp. The composition of the kernel is given by B. Corenwinder, in *Comptes Rendus*, as—

Water	5·000
Oil	62·175
Nitrogenous substances	22·653
Non-nitrogenous substances	6·827
Ash	3·345

The composition of the cake after decortication and expression of the oil was—

Water	10·25
Oil	5·20
Nitrogenous substances	47·51
Non-nitrogenous substances	24·04
P^2O^5	3·65
K^2O	1·53
M^2O, CaO, SiO^2, &c.	7·19

BANIS POWDER. See Explosive Compounds.

BAOBAB, THE. *Adansonia digitata*, or the Monkey Fruit tree.

The use of the inner bark of this tree for the purposes of paper making was discovered by Mr. Joachim John Monteiro in 1858, but it was not developed by him until 1865, and since that time it has made but slow progress in securing a position such as it appears to deserve. The discoverer in his work on *Angola and the River Congo*, 1875, gives the following description of the baobab:—The baobab, or 'monkey fruit tree,' is well known from descriptions as one of the giants of the vegetable

kingdom. It rears its vast trunk thirty or forty feet high, with a diameter of three or four feet in the baby plants, to usually twenty to thirty feet in the older trees. Adansonias of more than thirty feet in diameter are rare, but they have been measured of as great a size as over 100 feet in circumference; the thickest trunk I have ever seen was sixty-four feet in circumference, and was clean and unbroken, without a crack on its smooth bark.

'The leaves and flowers are produced during the rainy season, and are succeeded by the long, pendent, gourd-like fruit, like hanging notes of admiration, giving the gigantic, nearly leafless tree, a most singular appearance. Millions of these trees cover the whole of Angola, as they do in fact the whole of tropical Africa, sufficient to supply an incalculable amount of paper material for years, but for the indolence of the negro race. . . . The leaves of the baobab when young are good to eat, boiled as a vegetable, and in appearance are somewhat like a new horse-chestnut leaf about half-grown, and of a bright green. The flowers are very handsome, being a large ball of pure white, about four or five inches across, exactly like a powder puff, with a crown of large thick white petals turned back on the top of it. After a few days the flowers become tipped with yellow, before dropping from the tree. The trunks of even the largest trees have, properly speaking, no wood, that is to say, a plank could not be sawn out of it, or any work made from it. A section of a trunk shows first a thin outer skin or covering of a very peculiar pinkish ashen white, somewhat like that of the silver birch, some appearing quite silvery against the colour of other trees and foliage; then there follows about an inch of substance like hard mangold wurzel with fibres; then the thick coat of fibrous inner bark, which readily separates; next, the young wood, very much like the inner bark; and lastly, layers of more woody texture, divided or separated by irregular layers of pith, the most woody part having no more firmness than perfectly rotten mildewed pine wood, and breaking quite readily with a ragged and very fibrous fracture. The centre of these vast trunks easily rots, and become hollow from the top, where the stem generally branches off laterally into two or three huge arms. This is taken advantage of by the Quissama blacks, who inhabit the south bank of the River Quanza, to use them as tanks to store rain water in against a dry season.

'The hollow baobabs are very seldom open from the sides; I only remember one large tree of this kind in which an aperture like a door gave admittance into the empty centre; this was in Cambambe, and the hollow was large enough for two of us to sit inside. . . .

'The inner bark of the *Adansonia* is obtained by first chopping off the softer outer bark of the tree with a matchet and then stripping the inner bark in large sheets. The smaller trees produce the finest and softest fibre, and it is taken off all round the tree, which does not appear to suffer much injury. A fresh layer of bark grows, and is thick enough to take off in about six to eight years. The bark is only taken off the large trunks in places where the outer bark is smooth and free from knobs, &c. In the course of time, the trunk growing, shows the scar, high above the ground, of the place where the bark has been taken off years before. The layers of the inner bark when cut are saturated with sap; the pieces are beaten with a stick to soften them, and shaken to get rid of some of the pithy matter attached to them. The bark is then dried in the sun, when it is ready for pressing into bales, and shipping.

'The inner bark is put to a variety of uses by the natives. It is twisted into string and rope for all sorts of purposes, or used in strips to secure loads, and to tie the sticks, &c. in making their huts. Finer pieces are pulled out so as to resemble a coarse network; and the edges being sewn together make handy bags for cotton, or gum, grain, &c., and very strong bags are woven from thin strips, in which coffee and ground nuts are brought down from Cazengo to the coast.'

Mr. Monteiro was long engaged in establishing houses on the coast in Angola for bartering the Adansonia fibre, pressing and shipping the same to England. He says: 'In my long and arduous task I have met with more than the ordinary amount of losses and disappointments from commercial failures and other causes than seem to fall to the lot of discoverers or inventors in general, but I have triumphed over all obstacles and prejudices, and have established its success as a paper-making material beyond doubt.'

BARIUM. (Vol. i. p. 290.) *On the Preparation of Metallic Barium.*—This metal is usually obtained in a pure state by the decomposition of chloride of barium by means of a strong galvanic current; but this method, requiring a powerful battery, is very expensive. For the purpose of studying the properties of barium, the following methods were used:—

1. Metallic barium was obtained by strongly heating barium oxide (BaO) with metallic potassium, from which the barium was extracted by mercury; the residual

barium amalgam was heated, the mercury distilled over, and pure barium was obtained.

2. Barium was also obtained in the form of mercury amalgam by a double composition of a concentrated solution of chloride of barium in water, and of sodium and mercury amalgam, as shown in the equation—

$$(nHgNa^2) + BaCl^2 = (nHgBa) + 2NaCl.$$

As a small quantity of metallic sodium may remain free during this reaction, it is better to take an excess of chloride of barium: in this case a pure barium amalgam is obtained. The amalgam is quickly washed from the chloride of sodium in a cap with water, dried and heated to set free the mercury. A description of this process may be found in every manual of chemistry.

It is understood that by washing the barium amalgam by water we oxidise in the same time the barium, which readily decomposes water, with a solution of hydrogen and formation of barium hydrate (H^2BaO^2); so that if we perform the operation of washing the amalgam very quickly, even then we lose a considerable quantity of metallic barium. However, this process for obtaining barium is a difficult one; the only modification which may be proposed is to collect as quickly as possible the barium amalgam, to dry it between filtering paper, and to heat it strongly; then the mercury and the chloride of sodium, in the form of vapours, fly away. The specific gravity of the barium obtained by the processes mentioned above was found to be 3·75: it is a whitish metal, slightly volatile. The dry atmosphere has no action upon it; but it is readily oxidised at ordinary temperatures by water, with the formation of H^2BaO^2. The metal seems to be rough and ductile. Ordinary acids attack the metal, with the formation of corresponding salts.

Signore Limpo proposes a far easier method, consisting in the preparation of pure iodide by barium (BaI^2), and obtaining the barium by the decomposition of the iodide of barium by means of metallic sodium. The operation may be divided into 2 distinct parts:—

1. *Preparation of Pure Iodide of Barium.*—This salt may be prepared by acting on barium hydrate of iodine; the operation is made in water slightly heated by a spirit lamp. We obtain then two salts, iodate of barium ($Ba(IO^3)^2$) and barium iodide (BaI^2), by the reaction—

$$6H^2BaO^2 + 6I^2 = 5BaI^2 + Ba(IO^3)^2 + 6H^2O.$$

The $Ba(IO^3)^2$ is decomposed into BaI^2 by passing a current of sulphuretted hydrogen through the solution; we obtain then—

$$Ba(IO^3)^2 + 6H^2S = BaI^2 + 6S + 6H^2O.$$

The barium iodide is filtered from the sulphur, evaporated and dried.

2. *Preparation of Barium.*—The barium iodide is powdered and mixed with an equivalent quantity of sodium. The mixture is thrown into a covered iron crucible and heated. Strong reaction takes place with the evolution of light and heat; the reaction is a very simple one:—

$$BaI^2 + Na^2 = 2NaI + Ba.$$

The pure metal may be extracted from the mixture by means of mercury and distilling the barium amalgam. By this process the barium was obtained in a more compact mass. In all the experiments a strict analogy was observed between metallic barium and calcium; strontium may be supposed to resemble much these two metals, but the difficulty of obtaining the strontium in a pure state was an obstacle in studying the properties of this metal.—*Chemical News*, No. 810, p. 243.

BARIUM HYDRATE. (Vol. i. p. 294.) Rosenstiehl states that crystallised baryta melts in its water of crystallisation at 75° C.; the crystals then contain 45·97 per cent. of BaO.

Caustic baryta may be prepared from heavy spar by decomposing the mineral, mixed with coal or charcoal and sawdust, in a furnace, extracting the sulphide of barium with boiling water out of contact with the air, and decomposing it with 1½ equivalent of oxide of zinc. The hydrate obtained by evaporating the solution may be converted into anhydrous baryta by heating it in earthern cylinders in a steam of carbonic oxide.—*Bull. Soc. Chim.* (2) xii. *Dingl. polyt. J.* ccxviii.

BARIUM IODIDE. See Barium.

BARK. Our trade in the varieties of bark, used by tanners, or such as is employed medicinally, has been during 1874 and 1875 as follows:—

Bark for Tanners' or Dyers' Use, Unenumerated.

Imports	1874		1875	
	Quantity	Value	Quantity	Value
	cwts.	£	cwts.	£
From Holland	20,072	6,300	34,507	12,094
,, Belgium	117,112	33,264	155,865	60,220
,, Spain	...	...	11,066	4,544
,, Italy	9,296	4,758	...	...
,, Algeria	27,865	10,695	26,546	11,076
,, United States of America	23,363	14,655	33,883	16,619
,, Australia	117,535	57,041	182,613	132,881
,, other Countries . .	6,440	2,186	72,432	9,512
Total	324,703	128,899	471,900	247,910

Extracts of Bark or other Substances to be used in Tanning or Dyeing.

Imports	1874		1875	
	Quantity	Value	Quantity	Value
	cwts.	£	cwts.	£
From Belgium	...	...	...	6,797
,, France	...	9,291	...	28,106
,, United States of America	...	29,956	...	69,846
,, British North America .	...	18,380	...	41,019
,, other Countries . .	...	5,816	...	1,631
Total	...	63,449	...	147,399

Peruvian Bark.

Imports	1874		1875	
	Quantity	Value	Quantity	Value
	cwts.	£	cwts.	£
From Germany	757	8,856	331	3,840
,, France	812	9,527	912	10,124
,, United States . . .	1,186	9,100	...	...
,, New Granada . . .	25,450	254,693	23,329	235,066
,, Ecuador	4,957	49,146	3,591	35,824
,, Peru	5,972	69,359	5,270	55,371
,, Chili	640	10,609	704	10,684
,, Brazil	1,316	20,629	749	6,421
,, other Countries . .	1,094	10,271	1,595	16,829
Total	42,172	442,241	36,551	374,160

Of Other Sorts.

Imports	1874		1875	
	Quantity	Value	Quantity	Value
	cwts.	£	cwts.	£
From United States of America	5,914	3,400	9,268	4,630
,, Australia	...	...	1,960	1,440
,, New Granada . . .	2,849	8,685	...	...
,, other Countries . .	3,167	8,662	2,417	6,070
Total	11,930	20,747	13,645	12,140

BARLEY (Vol. i. p. 290), *Examination of, for Sugar and Dextrin.* In ungerminated barley there are, according to C. KÜHNEMANN, three substances which interfere with the detection of sugar. These are a substance which he calls *Sinistrin*, difficultly soluble in cold water, and having lævorotary powers; another easily soluble in water, and precipitated by alcohol; and thirdly, a non-volatile organic body. The sugar was separated in the following manner:—

A considerable quantity of barley in a finely divided state was exhausted in 95 per cent. of alcohol, the extract mixed with twice its weight of ether, and the liquid agitated with about one quarter of its weight of distilled water. The aqueous solution, after being separated from the supernatant ethereal layer, was examined and found to polarise light. It contained two kinds of sugar: one which reduced copper solution, and one which did not. The latter is crystalline, and appears to be identical in its properties with cane sugar.

The exhausted malt was dried at 100° C., and further exhausted with cold water. The extract was mixed with six times its volume of absolute alcohol. The white flocculent precipitate produced was collected, dissolved in a small quantity of cold water, and again precipitated by alcohol. It then gave characteristic reaction differing from those of dextrine.

These researches show that neither germinated nor ungerminated barley contains dextrine, but crystallisable sugar and other organic bodies.—*Deut. Chem. Ges. Ber.* viii.

BAROMETER. (Vol. i. p. 292.) In the short article referred to, it was then thought advisable to confine the attention simply to the use of the instrument as an indicator of danger in our coal mines. It must be evident to everyone that the slightest variation in the weight of the barometric column must have considerable effect on the conditions of the air in a coal mine. We have the stagnant air (we can scarcely use any other term) of the mine itself to deal with, which is constantly liable to special movements, as the great mass of the atmosphere is moved; and we have the air contained in the coal itself, which is, of course, liberated as there is any reduction in the pressure of the air by means of which it is confined in the interstices of the coal. The barometer, by indicating the true conditions of atmospheric pressure, is a very useful instrument to those who have been taught to use it aright.

There have been several modifications of the barometer which are well worthy of notice, some of them being especially applicable to the use of the miner, seeing that very often small movements in the mass of the atmosphere may give rise to important changes in the air, as it exists in our subterranean workings. But it is essential that the miner should be instructed to read those slight changes aright. The great necessity of the present time, when so much is said and written about scientific education, is a correct appreciation of the value of minute phenomena.

A very sensitive Mercurial Barometer has been proposed by Dr. FREDERICK GUTHRIE. In a communication to the Physical Society on January 20, 1877, he thus describes his invention:—

'The object aimed at is to get a barometer which shall combine great sensibility with sufficient compactness. The barometers depending upon the weight of liquid columns are, unless the liquid is mercury, of unwieldy length. DESCARTES suggested a modification of the mercurial barometer, in which the air-supported column of liquid consists of two liquids, the lower one being mercury and the other one water, holding tartar emetic in solution to ensure the expulsion of air. Now that we know various liquids, notably hydrocarbons which have no sensible vapour tension at atmospheric temperatures, it is surprising that this form has not been re-introduced. It appears, however, to be little known. It was suggested to me by a friend; and I made one containing glycerine, and used it with success for some months before I was aware of its having been suggested by DESCARTES. The sensibility of such a barometer would obviously be, if the upper liquid were without weight, directly proportional to the ratio between the sectional areas of the cylindrical chamber and the upper tube (if also the open limb were of infinite area). But the upper liquid having weight, the limit of sensibility is the comparative density of the mercury and liquid (say 16 : 1). Accordingly, this limit is reached upon the cylindrical chamber, and has four times the diameter of the upper tube.

'By inclining the top part of the supported column a theoretical increase of sensibility is obtained; but practically, on account of the dragging on the column and for other reasons, this device is not in use for exact measurements. The multiplication of motion caused by applying a float connected with a wheel, as in the common weather-glass, is for similar reasons to be discarded for such purposes. Aneroid barometers are of exceedingly convenient form, but are of course saddled with the objection that the metal chamber is never perfectly elastic, so that they require frequent comparison with standard mercurial ones.

'My friend, the late B. F. Duppa, devised a barometer in which the cistern or open limb was dispensed with, and was replaced by an open horizontal capillary tube. The free surface of the mercury in the capillary tube would then move at a rate proportional to the sectional areas of the vacuum end and the capillary. I believe this plan was not found to answer, on account of the oxidation of the free end of the mercury.

'The plan which I submit, and which in the models I have made and have had made appears to succeed well, more resembles that of M. Duppa than of any other with which I am acquainted. One form consists of an ordinary barometer tube, B, 6 millims. in internal diameter, connected by a flat horizontal spiral, s, of 2 millims. internal diameter, with the open tube, c, of the same diameter as B. In s is a bubble of air, e, at such a distance from B that it cannot enter B when the mercury in that tube is at the top. The motion of the bubble is, of course, 9 times as fast as that of the level of the mercury in either limb, or 4½ times that of the true barometric variation. The object of bringing B and c together is to avoid as much as possible the effect of the relative differences of height on change of place. In another form (which is being made by Mr. Hicks, of Hatton Garden), the limb c is made to enclose hermetically the limb B. This should bring the effect of such relative tilting to a minimum. In one which I have myself made, the tube s being straight and placed on a stone mantlepiece, a drop of sulphuric acid is employed instead of the air-bubble. It has the effect of making the motion rather more nimble, but is perhaps not quite so trustworthy for exact measurements, because the wetting of the tube by the liquid causes some inconstancy in its calibre. A tube, s, of 2 millims. internal diameter, connected with a barometer tube having at its upper mercurial surface a diameter of 20 millims., would exaggerate barometric motion 100 times; and of course the sensibility would approach the nearer to twice this, the greater the diameter of the open limb. There is indeed absolutely no theoretical limit to the possible sensibility. It must be left to practical glass-workers to determine whether a spiral form is the best for the tube s, or whether a series of parallel tubes joined alternately end to end are to be preferred. According to Professor Dewar, who has had great experience in the use of such tubes for similar purposes, it would not be advisable to have the s tube less than 2 millims. internal diameter. In all cases, on account of the unavoidable irregularities in so long a tube, I presume as many as possible comparisons should be made with a standard barometer and the intermediate graduations introduced by interpolation. In the straight one mentioned above, the gap in the mercury thread is seen through a lens to be in constant agitation.'

2207

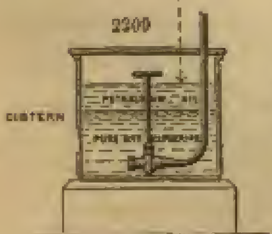
Mr. James Jordan has been very successful in the construction of barometers filled with water, and more especially with *glycerine*. An instrument of this class was erected in the late Exhibition of Scientific Apparatus at South Kensington, and is thus described:—

In this instance a column of glycerine, a liquid which is about one-tenth part of the density of mercury, is sustained in a glass tube by the pressure of the atmosphere, instead of a column of mercury, and the column is thus many feet long instead of many inches. The glass tube A (*fig.* 2208), which shows the top of the column and its oscillations, is joined below to a pipe at B, which is continued down the wall of the staircase to a large glass reservoir on the basement floor, and there has its open end plunged into a bath of glycerine, covered by a layer of petroleum, to prevent moisture being taken into it from the air (*fig.* 2209). The specific gravity of the glycerine is 1·26. The glass tube at the top, where the indications of rise and fall are given, has an area of one square inch, and the area of the cistern is 100 square inches. The tube is filled, in the first instance, by a very ingenious plan. There is a stopcock below in the cistern. This having been closed, glycerine is poured in through a stoppered cap at the top. The tube having been in this way filled to the brim, the stopper is firmly fixed into the open orifice above, and the stopcock below is turned. The glycerine then runs down into the cistern, but only until it reaches the height at which it is balanced in the tube by the pressure of the atmosphere upon the exposed surface below. There is

then a vacuum in the top of the closed tube above the glycerine, and the barometer is formed. The top of the glycerine moves up and down in the tube, as the pressure of the air is greater or less upon the liquid in the reservoir below. The vacuum at the top of the tube is good, because glycerine, under all ordinary conditions, does not give off any vapour to fill that space; whilst water, under the same circumstances, would fill the top of the tube with aqueous vapour, and even mercury has the defect of vaporising in the Torricellian vacuum. The average height at which the column of glycerine is sustained above the level of the cistern is 27 ft. When a mercurial barometer stands at 29·75 inches, the glycerine barometer stands at 321 inches. A change of a tenth of an inch of mercury corresponds to a change of an inch of the glycerine. The instrument is furnished with two scales, one having true inches engraved upon it, and the other the divisions which correspond to an inch of mercury at its fractional parts. As the cistern has an area 100 times that of the top of the column, the correction for capacity is therefore 1 inch for every 100 inches of the column in the tube.

2208

2209



The *Spiral Cord Barometer*, which is the invention of Staff Commander C. George, is a very simple method for filling the barometer tube at any time and under any circumstances, which commends itself more especially to the attention of travellers. The chief points are—

1. The spiral cord being kept in the tube while filling.
2. Using the cistern as a funnel.
3. The circular motion given to the spiral cord, acting on the dense body of mercury, forces the cord upwards and out of the mercury and with it the air-bubbles.
4. Vulcanised india-rubber stoppers for the cistern instead of cork, which will not stand the pressure.

Description of the Barometer.

Figs. 2209, 2210, and 2211 show the barometer set in the tripod stand, in which the following may be briefly noticed:—

A B C is the tripod stand, which forms the outer case when packed for travelling (*fig.* 2211).

a Is the tube.

b The upper stopper, through which the barometer tube passes into the cistern.

c The cistern.

d The lower stopper, on which the barometer rests, is supported upon a temporary tripod stand, or a large stone, block of wood, or box about one or two feet from the ground, to suit the height of the observer.

e A wood or ivory disc placed between 2 and 3; it rests upon the cistern, and the upper stopper and tube thus bear fairly and equally on the disc.

f A brass or zinc case to receive tube cistern, stoppers, and spiral cord (*fig* 2211).

The Stands.

No. 1 stand is of the tripod form, which when shut up has the zinc case inside it, contains the barometer tube, cistern, stoppers, and spiral cord, &c., is easily carried, and the barometer is well protected from accident.

No. 2 stand consists of a plain strip of wood, 3½ feet long by 3 inches broad, has two small tables which shut up on hinges, and by a button, fastened flat to the surface of the stand: the upper table has a hole in it to receive the tube when being filled.

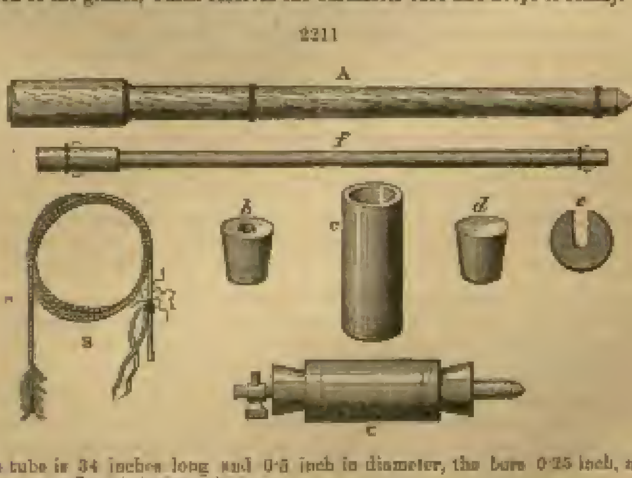
On the lower table the barometer rests for observation; the stand has a brass

bracket at one end, by which it can be hung to a tree or post, and thus placed perpendicular.

2210

The stand *c* is formed by screwing a long sharp gimlet into a tree or post, a ring is fastened to the gimlet, which receives the barometer tube and keeps it steady.

2211



The tube is 34 inches long and 0·5 inch in diameter, the bore 0·25 inch, and the walls of the tube $\frac{1}{8}$th inch in thickness.

The tube is graduated by the maker as follows:—at $\frac{1}{2}$ inch from the open end is the commencement of the scale of the barometer, it is graduated upwards $1\frac{1}{4}$ inch,

and divided first into 0·1 inch, and these again are quartered, so that it can be read off by the graduations to 0·025, 0·050, and 0·075 of an inch, and can therefore be easily estimated to 0·01 inch.

The next mark is at 16 inches from the zero, which determines the height of 18,000 feet, or 180° of the boiling point: from 16 to 32 inches the small graduations recommence the same as at zero, so that a comparison of the levels of the mercury is read off to 0·01 inch.

Fig. 2211, *b* and *d.*—*The Stoppers* are of vulcanised india-rubber, in length 1·2 inch, size of large end 1·3 inch, size of small end 1·15 inch; they are warranted to stand a temperature of 32°, they will also bear the heat of the tropics; especially as the temperature of elevations is much below 60°.

c.—*The Cistern* is of glass, 3½ inches in length, 1·25 inch in the bore; wall of the cistern 0·1 inch; the centre lengthways is marked by a scratch.

e.—*The Disc* is a round piece of wood or ivory ⅛th of an inch larger in diameter than the cistern, on which it rests, and is 0·15 in thickness; a round hole is cut out of the centre, a trifle larger than the diameter of the tube; another piece is also cut out from the inner circle or hole, towards the outer edge of the disc; this enables it to pass clear of the tube, and lays flat on the top of the cistern; the upper stopper and the tube rest on this disc with a fair and equal bearing.

f.—*Brass or Zinc Case.* This case receives the tube, cistern, stoppers, and spiral cord, ready for use; it is lined with a soft padding to protect the tube and prevent breakage; each end has a clamp-like fastening, which can be tied with a string. This case and its contents are then stowed inside the tripod stand, and thus secured while travelling.

It is absolutely necessary to have the purest mercury that can be purchased, as the integrity of the observations mainly depends on its having no alloy whatever; no filtering process will rectify bad mercury. Just before filling the tubes, it will be found a good practice to force the mercury through a clean silk pocket handkerchief (doubled), by screwing up the corners, &c., until all has passed through; it may then be poured into the iron filterer, and is ready for use.

It must be poured from the filterer down the bore of the tube, and any quantity of mercury that does not pass into the orifice will be saved in the cistern.

Articles used in filling the Tubes. (*Fig.* 2211, 8.)—*The Spiral cord* is made of catgut, twisted, and performs a very important part, not only in filling the tube, but in cleaning it out. At one end is attached a small strip of calico, which is tied fast and well secured; this is passed down the tube to clean it out: at the other end of this cord is fastened the upper part of a crow's feather, which is passed down the tube after being cleaned out, and remains there while the tube is being filled.

C.—*The Filterer* is of iron, and is stowed in a wooden case, which serves for a trough to receive the mercury from the barometer when about to be packed away, and from thence the mercury is poured into the filterer, which is flat and oblong, fitted with two screw plugs; one of these being removed, into its place is screwed a nipple, with a very fine hole, through which the mercury is filtered into the orifice of the barometer tube when being filled; the other plug on being removed, into its place is screwed a small funnel to convey the mercury from the trough back into the filterer.

The Plumb-line is attached to the end of a piece of wire, the other end secured to a small cork that fits into the upper aperture of one of the spare stoppers; this stopper, with plumb-line, &c., fits to the upper end of the barometer, and can be moved round so as to test its being perpendicular, at right angles.

Directions for filling the Barometer Tubes.—1. A piece of glazed calico, about a yard square or more, should be spread out smoothly on the table or floor, the glazed side uppermost, to catch the mercury that may be spilled in practising the operation of filling, and to receive the globules that must be shaken off the spiral cord every time it is withdrawn from the tube, and the spiral cord wiped with a duster on to the glazed calico.

2. The india-rubber stoppers are marked with a black ring round them, which shows the depth they must be screwed into the cistern; the stoppers, as supplied by the maker, are in their proper places, and there is no occasion at the first filling to move the stopper through which the tube is passed. To fill the tube, you need only to remove the lower stopper, *d*, and, in replacing it, must force it into the cistern with a screw-like motion of the stopper one way, and at the same time a screw-like motion of the cistern the opposite way; in thus screwing in the stopper, it may take a somewhat slanting direction, this is rectified by reversing the motion of the stopper and the cistern, and thus screw it into the black mark. This should be practised two or three times on the empty tube and cistern, it is like putting a cork into a bottle, the latter being too small for the cork.

3. To clean the cistern, take it off the upper stopper, *b*; this must be done

with the same careful screw-like motion as in putting it on, so as not to bring the cistern into contact with the end of the tube, as it may damage it; the rule for placing on the cistern is to bring the end of the tube half-way into the cistern, which is the best place for it, on account of the motion when reversing the barometer after filling it.

4. Begin by cleaning the cistern outside and in with a clean dry duster, and then the outside of the tube with the same; pass the end of the spiral cord, with the calico attached, down the bore of the tube, and sweep out all the particles of dust, and whatever impurities may have got in; pass the open end of the tube through the stopper, No. 2, which has a hole in it, and let it project about 1½ inch, so as to reach the middle of the cistern, which now put on with a screw-like motion, and place it on the stand, cistern uppermost. Then thrust the feather end of the spiral cord down to the bottom of the tube, and let it remain there.

5. Now take the filterer, and pour the mercury into the orifice of the tube until it is one-third filled. With the forefinger of the right hand move the spiral cord round rapidly from left to right, and when it has wormed its way out of the mercury, withdraw the laden feather from the tube; clean the feather end of the spiral cord, and put it in again to the bottom of the tube.

6. Repeat the filling up of the mercury one-third more, and renew the same action with the spiral cord; clean the feather once more, re-introduce it, and, having filled up the mercury to within three-quarters of an inch to the top of the cistern, withdraw the feather with the same motion as before, and carefully fill up the space left by the spiral cord with mercury to within an inch of the top; brush round the cistern with the feather-end of the spiral cord.

N.B.—When giving the spiral cord circular motion in the tube, as it worms its way upwards and out of the tube, when the spiral cord is too long to conveniently give it circular motion, on account of its striking against you, tie the end of the cord with a loose single knot, round the tube, under the stopper of the cistern, and it will be out of the way, and help to give the required motion.

7. This done, place the lower stopper, *d*, with a screw-like motion, firmly and evenly into the mouth of the cistern; place the top of the zinc tube on it, and the legs of the said top will reach to the stopper, *b*, and then with the right hand reversed make the legs nip the stopper, *b*; the cistern and stoppers thus secured, draw the barometer perpendicular out of the stand; and, still holding it thus firmly, steadily and slowly reverse the barometer, and replace it in the stand, reeving the upper end of the barometer through the hole in the upper shelf of the stand, *h*, and land the cistern on the lower shelf, and set it upright, and let it remain with the cover of the zinc tube, which affords it protection.

8. Lastly, raise the upper stopper, *b*, sufficiently to admit the ivory disc, *e*; set it perpendicular, and in the middle of the cistern, allow it to remain a few minutes, read off both scales, the upper one first; their difference is the reading of the barometer.

Do not use a reading glass of too great convexity, as it will cause parallax;—the convex surfaces are the proper ones to register, and the eye should be placed on the same level as the convex surface and at right angles to the tube, which is easily ascertained by noticing when the reflection of any mark of the graduation coincides with itself.

1. In emptying the tube, it should be noticed that the mercury always takes up a spiral form, somewhat like a corkscrew, with the handle held downwards; the same law has been followed in filling with a spiral cord, and turning it round the same way.

2. In comparing one of my barometers with one of Newton's of the same size, Newton's always fall with a concave surface, while my barometer always maintained a convex, whether rising or falling, thus making the daily differences more exact.

3. The largest sized barometers can be filled by this process, by only enlarging the spiral cord and adding more feathers.

Should the traveller have to ascend mountains over 10,000 feet, he must use precautionary measures to save the mercury that will overflow the cistern as it descends from the tube; this he will easily effect by removing the iron filterer from its case, and use it as a save-all trough, by securing it to the lower shelf of the stand, before he inverts the barometer, and then land it in the said trough;—afterwards, he may plunge the end of his wooden pencil into the cistern, and cause more mercury to overflow, which will leave clear space in the cistern to read off as at lower elevations.

The trough can then be removed, and the mercury poured back into the filterer.

For travellers visiting the Arctic regions, where the intense cold may somewhat affect the elasticity of the india-rubber stoppers, a cistern fitted with metal flanges and screw caps will be supplied as required.

This mercurial barometer is not intended to supersede either the boiling-point

thermometer or the aneroid, but to give them that assistance which they so much need, and the traveller who prefers using the boiling-point thermometer and the aneroid, may refer to it as a *standard* of comparison—and thus afford the means of placing a value on former observations.—*Quarterly Journal of the Meteorological Society*.

BARRELS, PAPER. See PAPER BARRELS.

BARYTA, GREEN. Two parts of finely powdered peroxide of manganese are gradually introduced into a fused mixture of 2 parts of potassium hydrate and 1 part of chlorate of potassium. The mass is heated to low redness, left to cool, powdered, treated with cold water, and filtered. Nitrate of barytes is added to the filtrate, and the violet manganate of barytes (barium manganate) is washed mixed with ½ to 1 part of hydrate of barytes (barium hydrate) and heated to low redness in a copper basin till it acquires a pure green colour. It is powdered and treated with water to remove free barium hydrate.—*Dingl. polyt. Jour.* ccxvi. 189. *Journal of the Chemical Society.*

BARWOOD. (Vol. i. p. 293.) This dye wood is fully described in the article referred to. The following new investigations by Dr. ANDERSON have considerable interest:—

Barwood contains at least 3 colouring matters; ether dissolves out 2 of these: one (A), which is less soluble, and obstinately adheres to the *baphiin* (a colourless substance obtained from barwood, having the formula $C^{12}H^{10}O^{4}$), and another more soluble (B), which is easily got rid of. After the extraction with ether is complete, alcohol dissolves a third (C). All are insoluble in benzol; all give purple lakes with acetate of lead, and purple colourations with alkalies.

(A.) The solubility of this body diminishes after exposure to air. It may be purified from baphiin by boiling with benzol. It is a bright red powder.

(B.) Crystalline dissolves easily in boiling alcohol. A strong solution cuts off the blue and nearly all the green of the spectrum, the blue first. The same solution mixed with hydrochloric acid becomes darker, transmits the blue faintly, and very much obscures the green; the yellow and red are transmitted. The solution, after the addition of the acid, on mixing with ammonia or potash, becomes deep pink; the green and blue are much obscured, while the red is left, and the yellow is cut off and replaced by a black band.

(C.) The green is more absorbed by this colour in alcoholic solutions than by (A). When the solution is moderately strong, a black band appears in the yellow. When hydrochloric acid is added, the green is more obscured, and the yellow is still decidedly effaced, notwithstanding the dilution; the blue is nearly removed, and the red remains. When ammonia is added to the solution after the action of hydrochloric acid, the colour becomes instantly purple; the red ray is transmitted, the yellow is effaced, the green scarcely visible. C acts on the green and yellow more than A.

N.B. It has been stated that the colouring matter of barwood is identical with Santonin. The above renders this very improbable.—*Educts from Baphia Nitida* (Barwood), by the late THOMAS ANDERSON, M.D., F.R.S. *Journal of the Chemical Society*, December 1876.

BASALT. (Vol. i. p. 295.) ZIRKEL divides basalts according to their microscopic constituents into—

1. *Felspatic Basalts*, consisting mainly of triclinic felspar and augite, always associated with magnetic and titaniferous iron, never with leucite.

2. *Leucite Basalts*, containing white leucite, augite, olivine, and magnetic iron ore.

3. *Nepheline Basalts*, chiefly composed of nepheline, olivine, and magnetic iron ore, and frequently with leucite.—*Jarbuch Mineralogie.*

BAUXITE. Bauxite from Ireland, analysed by SIEMENS, gave for the raw ore—

Silica	3·5
Alumina	35·0
Sesqui-oxide of iron	38·0
Oxide of titanium	2·0
Water	21·5

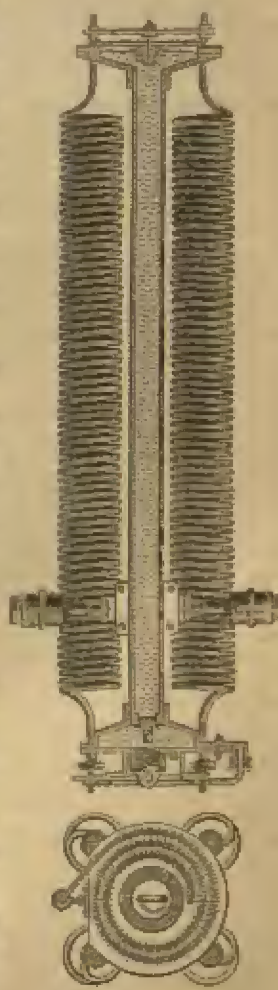
A variety obtained from Wochein in Carniola gave to the same chemist the following for the raw ore:—

Silica	6·29	Magnesia	0·36
Alumina	64·24	Soda	0·20
Oxide of iron	2·40	Potash	0·46
Lime	0·55	Water	25·74

Bauxite forms an excellent material for the lining of furnaces which have to bear an intense heat, as in SIEMENS' rotatory furnace. A series of experiments made by

Siemens', to form solid lumps by using different binding materials, have shown that 3 per cent. of argillaceous clay suffices to bind the bauxite powder previously calcined. To this mixture about 6 per cent. of plumbago powder is added, which renders the mass practically infusible, because it reduces the ferric oxide contained in the bauxite to the metallic state. Instead of plastic clay as the binding agent, water glass, or silicate of soda may be used, which has the advantage of setting a hard mass, at such a comparatively low temperature as not to consume the plumbago in the act of burning the brick. When the lining is complete, the interior of the bricks is preserved against oxidation by fluid cinder added to bind them together, which prevents contact with the flame. A bauxite lining of this description resists both the heat, and fluid cinder in a very remarkable degree. A rotative furnace at Siemens' Steel Works at Birmingham was lined partly with bauxite and partly with carefully selected plumbago bricks. After a fortnight's working the brick lining was reduced from 6 ins. to less than ½ in., whereas the bauxite lining was still 5 in. thick, and perfectly compact. Moreover, the bauxite, when exposed to intense heat, is converted into a solid mass of emery, of such extreme hardness, that it can hardly be touched with steel tools, and is capable of resisting mechanical, as well as calorific and chemical, actions to which it is exposed. The bauxite used for this lining contained 53·62 per cent. alumina, 42·26 ferric acid, and 4·12 silica.

2212



BATHOMETER. The name given by Dr. Siemens to an instrument for sounding depths at sea.

The principle on which the action of this ingenious instrument depends is the diminution of the influence of gravity, produced by an alteration in the density of the strata immediately below it. The density of sea water is about 1·026, and that of the rocky crust of the earth is about 2·75; it follows that the depth of sea water must exercise a sensible influence upon the total gravitation if measured from the surface of the sea.

In 1859, Dr. Siemens proposed a method analogous to that of the bathometer, for obtaining soundings, and made an attempt to construct an instrument which should indicate such slight variations in total gravitation as would require to be measured; but the difficulties connected with neutralising the effects of the variation in temperature and the motion of the ship were found to be very great. Within the last year, however, the exigencies of deep-sea telegraph construction have shown the value, and indeed almost the necessity, of having a depth indicator always to hand, and hence the instrument shown in our wood engraving (*fig.* 2212) as a diagram, not showing details, but only the principle of action.

The instrument consists of a column of mercury contained in a vertical steel tube, having cup-like extensions. The lower portion is closed by means of a corrugated steel-plate diaphragm, similar in construction to the plates employed in aneroid barometers, and the weight of the mercury is balanced in the centre of the diaphragm, by the elastic force of carefully tempered steel springs, whose length is the same as that of the mercury column. Both ends of the column are open to the atmosphere, so that its variations of pressure do not affect the readings of the instrument.

The elasticity of carefully tempered steel springs having been found by experiment to diminish in an arithmetical ratio with rise of temperature, but in a different ratio

to that of the dilatation and consequent diminution of the density of mercury, this had to be arranged for, in the mechanical construction of the instrument. It is evident that if the mercury were contained in a cylindrical vessel not varying in diameter, its potential would always be sensibly constant. If, on the other hand, two cups were connected by a tube of infinitely small diameter, the potential would diminish with rise of temperature, in the ratio of the expansion of mercury. The form employed in the instrument is a mean between these extreme forms, the ratio between the areas of the cups and that of the tube being governed by that of the diminution of the density of the mercury and potential of the springs.

The tube is throttled near its upper extremity, in order to diminish the influence of the ship's motion in causing oscillations of the mercury. The instrument is suspended in a universal joint, a short distance above its centre of gravity, in order to cause it to retain a vertical position notwithstanding the oscillations of the vessel, and it is contained in an air-tight casing, so as to be unaffected by atmospheric influences.

The reading of the instrument is effected by means of electric contact between the centre of the diaphragm and the end of a micrometer screw, the divisions on the rim and the pitch of the screw being so proportioned that each division represents one fathom of depth. Another mode of reading the instrument by means of a spiral glass tube fixed on the top of the instrument, and connected with the mercury in the upper cup by means of a liquid of less density, is now employed, and has been found to be successful in practice.

The indications of this instrument have been compared with soundings taken by means of Sir William Thomson's steel wire apparatus, and show a very close accordance. The following shows what kind of indications it has given. On October 31, 1875, according to soundings, the 'Faraday' was at noon in 82 fathoms, at 1.8 p.m. in 204 fathoms, and at 2.20 p.m. in 69 fathoms of water, whilst the bathometer readings were 83, 218, and 78, showing that the instrument indicated a passage from shallow into deep water, and back into shallow, in a period of two hours, with considerable accuracy.

The instrument may also be applied for measuring heights above the surface of the earth, such as in balloon ascents, but it is not to be relied upon for measuring the heights of mountains.

The instrument is chiefly useful in enabling the mariner to determine his position, when in foggy or cloudy weather he is unable to take observations. If the figure of the ocean bed was laid down more perfectly than at present upon charts, and such were in the hands of the mariner, he would be able to tell, by observing his bathometer, what was the approximate depth of water below him, and the direction in which, and the rate at which, the depth either increased or diminished; while by consulting his chart he would then be enabled to determine his actual position with considerable accuracy.

BEAN JUMBA. See Mimosa Seed.

BEER. (Vol. i. p. 300.) See also Malting and Fermentation.

The following analyses of beer are of so much interest that they are reproduced here from Watts's *Dictionary of Chemistry*.

Kind of Malt Liquor	Specific gravity	Percentage of			Original gravity of wort	Malt per barrel	Contents per pint		
		Alcohol	Extract	Acetic Acid			Alcohol	Extract	Acid
							fluid oz.	oz.	grains
Burton Ale . .	1040·58	5·88	13·35	·28	1121·63	4·09	2·16	2·77	20·12
Bass's Barley Wine .	1032·81	6·41	11·78	·28	1114·73	4·22	2·18	2·42	20·77
Edinburgh Ale . .	1006·63	4·41	3·64	·10	1045·38	1·77	1·12	·73	16·73
Guinness's Stout .	1015·81	6·91	6·17	·24	1076·06	2·66	1·74	1·35	31·22
Truman, Hanbury, and Co.'s Porter .	1018·16	4·62	5·13	·24	1051·22	1·90	1·05	1·01	31·27
Whitbread's Porter	1014·44	4·28	5·15	·18	1054·11	2·00	1·09	1·08	15·97
Hoare's Porter . .	1012·99	4·18	5·04	·18	1052·47	1·94	1·06	1·03	15·06
Perry's Ale . .	1006·48	3·87	3·66	·14	1043·89	1·69	0·99	0·73	7·07

The following analyses of Austrian beers will show the distinctive differences between them and the English beers given in the above table, the quantity of alcohol in the English beers being generally in excess:—

No.	Description		Colour according to STAMMER'S Scale	Density at 15°	Ash in percentages of the beer free from CO_2	Carbonic acid	A Alcohol	E Extract	W Water	Actual degree of fermentation	E/A
							Determined by means of BALLING'S Saccharimetrical Beer Tester				
1	Export bottled beer		10·5	1·0174	0·3040	0·25	3·90	6·18	89·92	7·46	1·57
2	Lager beer, St. Mayer	Draught	9·0	1·0160	0·2431	0·24	2·76	6·00	91·24	5·88	2·17
3	" Hütteldorf	Draught	10·0	1·0177	0·2600	0·18	3·07	6·03	90·23	7·08	1·85
4	" Liesinger	Draught	9·5	1·0170	0·2208	0·20	3·11	5·50	90·34	6·60	1·10
5	" Pilsener	Draught	8·4	1·0129	0·1074	0·14	3·45	5·15	91·30	6·60	1·42
6	" Chotzener	Draught	9·9	1·0120	0·1708	0·10	3·00	4·03	92·06	5·84	1·66
7	" Wittingauer	Draught	4·2	1·0100	0·2164	0·30	3·42	4·62	91·93	6·07	1·30
8	Export beer, bottled		9·7	1·0100	..	0·29	4·70	4·62	90·66	9·10	0·97
9	Prague " "		9·5	1·0100	..	0·29	4·05	5·00	90·73	8·29	1·27
10	" " Lager bottled		9·5	1·0128	0·1797	0·24	3·45	4·73	91·82	6·08	1·38
11	Ale		9·1	1·0204	0·2271	0·29	3·69	7·10	88·22	7·00	1·92
12	Tap-house beer		8·6	1·0120	0·1670	0·10	3·41	4·85	91·74	6·40	1·42
13	Ladies' beer		..	1·0181	0·2137	0·16	2·89	5·95	91·16	5·00	2·06
14	Lager		..	1·0178	0·3472	0·17	3·48	6·85	89·90	6·66	1·81
15	House		..	1·0285	0·3518	0·25	4·30	8·48	87·15	8·20	1·94

The 'actual degree of fermentation' is found by deducting the amount of extract in the fermented from that in the original beer.

Exportations of Beer and Ale.

	1874		1875	
	Barrels	Value	Barrels	Value
		£		£
To Russia	3,917	15,574	4,994	18,568
" Germany	7,397	28,882	7,353	26,578
" Belgium	5,428	20,177	5,911	20,344
" France	10,695	40,272	10,711	38,685
" China	3,014	17,818	3,772	20,652
" Japan	2,444	14,414	2,008	11,468
" United States, Atlantic	36,139	192,915	32,572	175,655
" " Pacific	9,134	48,405	6,168	35,443
" Foreign West Indies	17,867	113,654	14,557	90,753
" Peru	8,456	52,377	3,590	20,365
" Chili	6,212	36,242	2,939	17,227
" Brazil	16,476	100,743	10,829	65,298
" Uruguay	5,151	29,851	—	—
" Argentine Republic	8,318	50,189	3,758	25,032
" Channel Islands	7,366	22,330	6,680	20,538
" Gibraltar	13,449	45,244	14,620	47,866
" Malta	8,242	25,027	7,853	24,061
" British South Africa	20,800	96,005	22,006	99,121
" B. India, Bombay and Scinde	53,749	174,739	52,558	163,254
" " Madras	21,348	67,577	21,729	70,400
" " Bengal and Burmah	73,768	264,240	80,504	269,166
" Straits Settlements	6,490	31,132	3,889	16,787
" Ceylon	9,856	37,376	8,132	29,549
" Hong Kong	5,514	25,981	7,609	29,984
" Australia	118,418	567,744	97,425	458,160
" British North America	17,488	80,647	14,189	61,920
" British West Indies and British Guiana	30,129	121,055	27,492	109,523
" other Countries	31,501	140,215	32,040	137,622
Total	559,413	2,449,035	504,511	2,094,672

Trade of the United Kingdom.

Importations of Beer and Ale.

	1874		1875		Duty and when imposed
	Barrels	Value	Barrels	Value	
Mum—		£		£	
From all Countries .	12	62	1	7	1l. 1s. per barrel June 1, 1880
Spruce—					
From Germany .	2,230	14,909	2,104	15,429	1l. 1s. and 1l. 4s. according to s. g.
" other Countries	2	15			
Total . .	2,232	14,924	—	—	
Of other Sorts—					
From Norway . .	374	1,356			8s. to 16s. according to s. g.
" Germany .	322	1,684	262	1,030	
" Holland . .	372	1,255	398	1,124	
" Belgium . .	991	4,025	1,182	4,646	
" other Countries	316	1,058	702	1,072	
Total . .	2,375	9,378	2,544	9,372	

Beer, Examination of, for Foreign Substances.—Two kinds of materials are supposed to be used to adulterate beer, sweet and bitter. Of the former, starch, sugar, and glycerin are mentioned, but these are probably not used to any extent. Of the latter, menyanthin, gentipicrin, colchicin, colocynthin, picrotoxin, brucin, strychnin, quassin, and absynthin, are supposed to be more or less employed. The first two and the last two of these are harmless. Those decidedly injurious are colchicin, picrotoxin, brucin, and strychnin. To detect these, the following process is recommended by WITTSTEIN. A litre of the beer is concentrated into a thick syrup. This is then poured into a glass cylinder, and five times its weight of spirit of wine of from 93 to 95 per cent. added, and the whole, after vigorous stirring, allowed to stand twenty-four hours. The alcoholic solution is then poured off, and the treatment repeated. The two solutions are united, and the alcohol is expelled. Dilute a small portion of the syrup-like residue with three times its quantity of water, and place in this a strip of white woollen cloth. After an hour, if the cloth remains white, there is no picric acid present, which, if present, would colour the cloth yellow. The remainder of the syrup is treated with six times its weight of pure benzine, 80° boiling point, and vigorously shaken. The benzine then is poured off, and the operation repeated. The two quantities of benzine are then evaporated. The residue may contain brucin, strychnin, or colocynthin. To test for these, put three small portions of the residue on porcelain. To one add a little HNO^3 of 1·33 to 1·40 sp. gr. If a red colour is produced, brucin is indicated. If a violet colour is produced, colchicin is present. To the second portion a little conc. H^2SO^4 is added. A red colour indicates colocynthin. To the third portion H^2SO^4 and a bit of red chromate of potash is added. A purple violet colour indicates strychnin. The residue of the spirit is freed by heating from the last traces of benzine and then treated with amyl-alcohol, 132° boiling point. If the amyl-alcohol is tinged of a wine red or a golden yellow colour, picrotoxin or aloes is indicated. To distinguish between these, a little of the alcoholic solution is put on a glass plate and allowed to evaporate at the ordinary temperature. If a white crystalline mass appears on the plate, picrotoxin is present; if not, aloes is indicated. The portion of syrup remaining after treatment with benzine and amyl-alcohol is freed from all amyl-alcohol and then treated with ether. This dissolves absynthin and the bitter principle of hops. The former gives with H^2SO^4 a reddish yellow, which readily passes into indigo blue. Finally the syrup treated with ether is still to be tested for gentian, menyanthin, and quassin. For this purpose, expel the ether, then dissolve in water and filter. To a portion of the bitter filtrate add an ammoniacal solution of silver and warm it. If the solution remains clear, quassin is present. If a silver mirror is produced, it arises from either gentine or menyanthin. Another portion is dried in a porcelain dish. To a part of the residue add concentrated H^2SO^4. If no colouration ensues, or if, by heating, a carmine red is produced, it indicates gentine. If, however, a yellowish brown appears, which passes gradually into a violet, then menyanthin is indicated.—*Archiv du Pharmacie* and *The American Chemist.*

BEESWAX, ARTIFICIAL. (Vol. i. p. 333.) An article is now (1877) being sold for beeswax which is a mixture of paraffin and common resin. The artificial article is, however, usually covered with a skin of real beeswax.

According to a chemical examination of the artificial beeswax, the appearance of which is well calculated to deceive, as the compound is almost identical in looks with the genuine wax, whilst in colour, brittleness, fracture, and adhesiveness the difference is very slight. The outer surface of the sham article possesses the characteristic honey-like smell of genuine wax, as genuine wax is on the surface; but freshly broken surfaces have a marked pitchy odour. Melted at a gentle heat, the smell of honey is lost, and the pitchy odour asserts itself in an unmistakeable manner; at a stronger heat it becomes intense, and persists for a long time. The melting point of the false wax is about 160° Fahr., and its specific gravity about 0·962. In its further qualitative examination 1 gram was warmed with 10 grams of chloroform in a small flask. The solution was clear and yellow, but soon became turbid on cooling, and an almost transparent, colourless, serous mass separated, more particularly upon the walls of the flask. Afterwards 1 gram was dissolved in 15 grams of 70 per cent. alcohol by boiling, and allowed to cool. In the clear yellow coloured solution round and half round colourless granules were deposited, free of resin. These were recovered by filtration, dried in the air, and weighed: 6 decigrams were thus obtained. The specific gravity of these granules was 0·910. The filtrate was evaporated at a gentle heat, and left as residue a brittle resin of a beautiful dark yellow colour, weighing about 4 decigrams. Further, 1 gram in raspings was boiled, and well shaken in a solution of 1·4 gram borax in 20 grams of distilled water. A colourless mass separated on the surface of the liquid in the vessel. The liquid was turbid, but on cooling was neither milky nor gelatinous. The same experiment was made with the granules free from resin. This time the fluid remained clear during boiling and when cooled. The granules united into a cake at the top of the fluid. A sample of fine shavings was then agitated with diluted ammonia solution; a portion of the residue above mentioned, free from resin, was also treated with ammonia. In both cases the fluid remained clear and transparent, and the samples unchanged, indicating the absence not only of stearin, but also of carnaubin and oleates. The granular body, which contained neither stearin nor Japan wax, was now tested for paraffin. It had a lustrous appearance and alabaster-like transparency, yielded between the fingers without adhering, and dissolved easily and completely in oil of turpentine and benzin, but not at all in absolute alcohol. The quantitative analysis brings out the quantities as 60 per cent. paraffin, and 40 per cent. of yellow resin.

BEET. (Vol. i. p. 334.) Dr. Voelcker has published in the *Journal of the Agricultural Society* numerous analyses made by him of the sugar beet. In 1869,—

English Roots gave him 8 to 12 per cent. of sugar
Irish Roots „ 6 to 11 „ „

In 1870—

English Roots gave him 9 to 15·3 per cent. of sugar
Irish Roots „ 10 to 14·8 „ „

The distribution of mineral substances in beetroot has been studied by several chemists.

MM. E. Frémy and P. Dehérain have grown beetroots under artificial conditions to ascertain the effect of various soils and manures in the production of sugar. The experiments were too extensive to be properly represented here: the original paper must be referred to (*Comptes Rendus*, lxxx. 778). The differences were very great, and so irregular that the authors cannot explain the differences observed.

It was found the roots poor in sugar contain a much larger proportion of albuminous matter than roots which are rich in sugar; and as roots grown in very fertile soil were poor in sugar, the question arises, is not an excessive quantity of nitrogenous manure detrimental, by causing a tendency to the formation of albuminous matters rather than sugar?

M. Pagnoul says, after five years' experience he finds: 1. Beetroots are richer in sugar in proportion as they are grown close together. 2. The poorer such roots are in saline matter, the richer are they in sugar. 3. The chlorides in the ash are greater in proportion as those salts are more abundant in the soil and in the manures used. 4. The proportion of other alkaline salts contained in the roots does not depend on the richness of the soil and manures in saline matters, but on their richness in nitrogen.

M. L. Lagrange says that the sulphate of ammonium is a good manure in beetroot

culture, as it increases the amount of sugar, and gives a greater value to the pulp. The salt appears to be easily decomposed by the beet, the ammonia is assimilated, and the sulphuric acid, neutralised by the alkaline and earthy carbonates in the soil, affords nourishment to the plants.—*Comptes Rendus*, lxxx. 631.

CORENWINDER has examined the Italian beet from Milan, Modena, Bologna, and other places. The Italian roots were poor in sugar, and contained much saline matter. 1 Litre of juice gave 52·5 to 65 grams of sugar, and from 10·2 to 16 grams mineral salts, the French roots giving 90·7 to 132·4 grams of sugar, and 7·3 to 8·7 grams of salt per litre. Analyses made on 3 samples of French roots grown with different manures gave for 1 litre of juice as follows, for the salts contained:—

	No manure	Chemical manure	Earth nut-cake manure
	grams	grams	grams
Chloride of sodium	1·238	·798	1·611
Potash	2·306	2·327	2·315
Soda	·992	1·125	·600
Lime	·216	·160	·371
Magnesia	·322	·293	·231
Sulphuric acid	·406	·201	·162
Phosphoric acid	·581	·657	·144
	5·973	5·561	5·833

The distillation of spirit from beetroot is largely practised on the Continent. Mr. CAMPBELL of Buscot has lately commenced it in this country. Beetroots are prepared for fermentation by several processes. The roots are pulped or sliced, mixed with a little sulphuric acid, then pressed, and the juice fermented.

The roots when sliced are treated with hot wash, acidulated with sulphuric acid; no press is used, the sugar being extracted by displacement (CHAMPONNOI). The slices of beetroot are placed in vats and fermented without previous treatment (LEPLAY). Beetroot is liable to contamination with fusel oil; but careful distillation removes this. The residual pulp after either of the above processes is good cattle food.

Beetroot is used to adulterate wines: for the best means of detecting it, see WINES.

BENZENE. (See BENZOL, vol. i. p. 337.) For detecting benzene vapour in coal gas, see COAL GAS.

BERAUNITE. A mineral like Vivianite, formerly found only as a pseudomorph, in the Hobek iron mine at St. Benigna in Bohemia, has been discovered in the Father Abraham Mine at Scheibenberg in Saxony upon brown hæmatite.

It forms laminæ and radiate groups, colour hyacinth red, streak yellow. Analysis gave $5Fe^2O^33P^2O^5 + 14H^2O$.—FRENZEL, *Jarbuch für Mineralogie*.

BERLIN SANDS. These sands, which are found to be excellent moulding sands, exist in the brown coal formation, or in the diluvial formation of the Mark in the coal measures of Wettin. They are imported into England, and used in some of our foundries for the finer kinds of castings. See SANDS *for moulding*.

BERTHIERITE. (See ANTIMONY, vol. i. p. 196.) $FeS_3Sb^2S^3$, containing 56·67 per cent. of antimony. It is sometimes found in large quantities associated with grey antimony. It has been discovered at Padstow in Cornwall, and at the Mine Neue Hoffnung Gottes, near Freiberg. Von HAUER found it to contain—

Sulphur	30·53
Iron	10·16
Antimony	59·30

Jarb. k.k. Geol. Reichs.

BERTHOLLETIA. A genus of *Lecythidaceæ*, a native of Guiana, Venezuela, and Brazil. One species, *B. excelsia*, yields the Brazil nuts of the shops, and the fibrous bark is used instead of oakum for caulking ships.

BERYL. See EMERALD.

BETAINE. A base occurring in the molasses of the beet. It is also found in the mangold wurzel. See WATTS's *Dictionary of Chemistry*, Supplements 1 and 2.

BESSEMER STEEL. See STEEL, BESSEMER.

BIOTITE. One of the magnesia micas, called also hexagonal mica, uniaxial

mica, &c. It has lately been found in Portland, and in Middletown in Connecticut, U.S.

The *biotite* of Portland is black, and possesses a high lustre. In thin plates it is transparent, clear, and brown by transmitted light. It is optically uniaxial. Specific gravity 2·96. When heated before the blowpipe, it imparts to the flame the characteristic carmine red colour of lithia, and it appears thus to differ from all the described varieties. Mr. George W. Hawes, of the Sheffield Laboratory of Yale College, gives the following analysis, showing that it is a lithia-bearing variety:—

Silica	35·61
Alumina	20·03
Ferric oxide	·13
Ferrous oxide	21·85
Oxide of manganese	1·19
Magnesia	5·23
Potash	9·69
Soda	·52
Lithia	·03
Titanic acid	1·46
Fluorine	·76
Chlorine	trace
Water	1·87
	99·27

The American Journal of Science and Arts, June 1876.

BISMUTH. (Vol. i. p. 346.) Its occurrence in Canada is thus described by the Geological Survey of the Dominion:—Sulphide of bismuth was several years ago obtained in the township of Tudor, Oregon. The ore, however, was for the most part only sparsely disseminated in a veinstone of quartz, which also held graphite and black tourmaline. At the surface small quantities of carbonate of bismuth were found; but lower down this was replaced by the sulphide, with traces of metallic bismuth. The vein in places was over 2 ft. in thickness, and traversed hornblendic rocks belonging to the Hastings series.

Bismuth has been found in the New England District of New South Wales, between Oban and Tenterfield. In the same district the hydrated carbonate of bismuth has been found in rounded grains.

In Tasmania a fine deposit of this metal has been found. Mr. Wintle thus describes its mode of occurrence:—

'Mount Ramsay is better known for the remarkably rich and large lode of bismuth. This is said to be between 30 and 40 ft. in width, while it has been traced for a considerable distance. This valuable discovery was made after I left the locality, while a party was prospecting for tin, which latter metal, in a native state, they at first took it to be. As is often the case, the bismuth is associated with considerable quantities of Wolfram.'—*Stanniferous Deposits of Tasmania,* by S. H. Wintle, of Hobart Town.

A specimen of native bismuth from Peru, analysed by G. Barth, gave 93·372 per cent. of bismuth, 4·570 of antimony with a trace of tin, and 2·058 of copper, with a little iron.

Field and Abel (*Chemical Society's Journal,* xvi.) state the bismuth can be detected in most of the native sulphides of copper in about the same proportion as silver in galena.

Vogel gives the following process for extracting bismuth from ores not containing lead:—The stamped ores are mixed with 58 per cent. of wrought-iron filings, and, according to the richness of the ore, with from 15 to 50 per cent. of soda, 5 per cent. of lime, and 5 per cent. of fluor spar. Arsenic and sulphur, with cobalt and nickel separate in the form of speiss, and the bismuth is obtained in a metallic state. This process is employed at Joachimsthal.

Bismuth may be deposited on copper or brass in a condition susceptible of a fine polish by using a bath containing from 25 to 30 grams per litre of double chloride of bismuth and ammonium, the solution being slightly acidulated with hydrochloric acid, one Bunsen cell only being necessary.

The objects on being taken from the bath are covered with a blackish mud, beneath which is the film of bright, firmly adhering bismuth.—Armand Bertrand, *Jour. Pharm. Chim.* (4) xxii.

Bismuth and tin unite readily when exposed on charcoal to the reducing flame of the blowpipe, but the fused mass immediately throws out excrescences, and becomes covered with a dense crust of oxides. The reaction is not, however, so striking as with lead or tin.—Chapman.

Bismuth renders wrought-iron cold-short, but it volatilises at the welding heat of the iron.

Bismuth, Double Hyposulphite of, and Soda. (Vol. i. p. 348.) M. A. CARNOT has prepared these new salts in the following manner:—

If into a slightly acid solution of chloride of bismuth we pour a concentrated solution of hyposulphite of soda, the liquid immediately becomes yellow, but it remains clear. If mixed with water there should be no turbidity, provided sufficient hyposulphite (3 grams to 1 gram of bismuth). The liquid, if left to itself, gradually changes, sulphide of bismuth being formed, and there is a formation of sulphates.

$$Bi^2O^33S^2O^2+3HO=Bi^2S^3+3(SO^3HO).$$

Heat favours this decomposition, and produces a deposit of sulphide in small black crystalline grains. The compound formed is a double hyposulphide of bismuth and soda.

CARNOT recommends this salt for the detection of potash.—*Chemical News*, September 15, 1876.

BISMUTHITE. This mineral is found, together with Joseite, at San José di Madureira, in Brazil. It is a hydrated carbonate of bismuth. The mineral is very soft. Its powder is grass green, which colour it retains when boiled in potash. On charcoal it melts easily.

BISMUTHOFERRITE. A silicate of iron and bismuth, from Schneeberg, in Saxony.

FRENZEL found it to contain—

SiO^2	22·08	24·05
Fe^2O^3	33·33	33·12
Bi^2O^3	43·26	42·83
	99·67	100·00

The massive green iron ore, containing bismuth—found at the same place—is probably a mixture of the above with another mineral.

BISMUTH OXYCHLORIDE. See DAUBREEITE.

BISMUTH OXYSULPHIDE. Bi^4SO^3 occurs native as *Karelinite*, in the Altai. An artificial oxysulphide may be prepared by heating the trioxide with sulphur to low redness in a retort.

BITUMENE. BERTHELOT gave this name to the least volatile of the hydrocarbons obtained by passing *benzene* vapour through a tube of porcelain heated to bright redness.

BITUMINOUS SHALE. (BITUMEN, vol. i. p. 352; NAPHTHA, vol. iii. p. 386; PARAFFIN, vol. iii. p. 502; SHALES and MINERAL OILS, vol. iii. p. 765.) The following condensed account of the occurrence of shales of a very bituminous character in the United States of America, is given by Mr. G. C. BROADHEAD, in *Mines, Metals, and Arts*:—

'Certain thinly laminated rocks, ordinarily termed bituminous shales or slates, occur in the Utica slate of the Lower Silurian system, as well as the Marcellus and Genessee of the Devonian rocks of Canada and New York. It is well known that similar beds are of frequent occurrence in our coal measures in every State where coal is found. Dr. T. STERRY HUNT has appropriately termed them "pyroschists," and defines them "to be argillaceous rocks, containing in a state of admixture a brownish insoluble and infusible hydrocarbonaceous matter altered to lignite or coal." We might add, that they are of a very dark brown or black colour, occurring in very even and generally thin layers. Some of these stratas contain, in the absence of oil wells, sufficient oil to distil for illuminating purposes.'

From the *Illinois Geol. Rep.*, vol. vi., we learn that there are 13 bituminous shale beds in the Illinois coal field, aggregating 34 ft. in thickness.

'In Missouri, our estimate is 21 beds, with an aggregate of 39 ft. This in a thickness of nearly 2,000 ft. of coal measures. A few of these blend into a cannel coal; for instance, certain beds in Johnson county, viz. PORTER'S, near Dunksburg; MCCLELLAN'S, six miles south of Warrensburgh; and TAYLOR'S, near Holden.

'The Breckenridge coal in Kentucky is also a similar cannel slate. From the latter there was formerly distilled a good quantity of illuminating oil; in fact, it was quite celebrated, but the discovery of the rich flowing wells of Pennsylvania suspended its production.'

The following table includes analysis of certain Kentucky pyroschists as determined by the Kentucky Geological Survey:—

	No. 1 Emmerson Co.	No. 2 Menifee Co.	No. 3 Wolfe Co.	No. 4 Wolfe Co.	No. 5 Breathitt Co.	No. 6 McLean Co.
Thickness	6 ft.	22 ft.	...	3 ft.	3 ft.	...
Specific gravity	1·302	...	14·34	1·353	1·36	...
Moisture	...	2·64	1·30	1·16	1·60	1·00
Vol. Comb'n	59·7	1·52	41·04	44·58	43·02	30·04
Total Volume	...	18	...	...	...	...
Coke	40·30	82·00	57·30	54·26	56·20	62·00
Ash	26·00	57·07	29·04	21·05	21·04	30·64
Carbon in Coke	...	24·03	28·02	32·76	33·60	33·03
Sulphur		...	0·84	0·50	2·55	...

Most of these are from the base of the coal measures. No. 1 is a cannel shale, which burns freely, is found under a considerable area in Butler Country, and is 6 ft. thick; No. 3 is also a cannel shale, which will form a pulverent coke; No. 4 is a cannel shale over 3 ft. thick.

West Virginia, Pennsylvania, Ohio, Indiana, Illinois, Missouri, Iowa, and Kansas, abound in similar bituminous shales.

The bituminous shales of Collingwood, Ontario, when distilled, yield 3 to 4 per cent. of tarry oil, which, when rectified, affords illuminating and lubricating oil. The available shale bed is 7 ft. thick, and its geological position the Utica slate. The best bituminous shales at the Albert mines yielded 63 gallons per ton, and 7,500 ft. of gas per ton. They belong to the carboniferous.

Bituminous shales are worked to some extent in Great Britain. The returns, however, have been but imperfectly made.

The *Oil Shales Returns* to the Coal Inspectors of late years have been—

	1873	1874	1875
	tons	tons	tons
Lancashire	60	837	4,118
Northumberland	1,511	...	...
Shropshire, &c.	...	...	3,084
North Staffordshire	6,617	3,101	9,000 [1]
South Staffordshire	...	...	360
North Wales	11,360	270	2,362 [2]
SCOTLAND.			
Western District	84,480	8,470	46,314
Eastern District	438,615	227,210	377,108
	542,643	316,483	442,036

BIXIN. (BIXINE and BIXEINE, vol. i. p. 566.) If the *Bixa Orellana* is crushed the red colouring matter of annotto is obtained. From this bixin may be prepared by digesting the dried alcoholic extract with ether, repeatedly treating the least soluble portion with hot ether, dissolving the remainder in alcohol, precipitating the alcoholic solution with acetate of lead, decomposing the washed precipitate with sulphuretted hydrogen, extracting the colouring matter with hot alcohol, and precipitating the alcoholic solution with water.

Dr. De Vrij prepared bixin from the fresh fruit of the *Bixa Orellana*. It is an amorphous body of the colour of vermilion.—BOLLEY and MYLIUS (*Bull. Soc. Chim.* (2) iii.).

'BLACKED' COAL. A coal is said in South Staffordshire to be 'blacked' when, by its near proximity to an igneous rock it has become so altered as to lose all its brightness, and nearly, if not quite, all its inflammability. (JUKES's *South Staffordshire Coal-field.*) This 'blacked' coal has recently been largely used for raising steam in locomotive engines, and a large coal proprietor has been burning his own 'blacks' in his household fires.

BLACK DIAMONDS. See DIAMONDS.

[1] The Chatterly Company returned to the Mining Record Office, 6,831 tons.

[2] North Wales returned to Mining Record Office, Coed Talon, 4,521 tons; Coppa, 1,800 tons; Nerquis, 2,532 tons.

BLACK ELDER. Dwarf Elder, used in adulterating wines. For their detection, see Wines.

BLACKING. Charred oak wood reduced to powder: it is employed for lining moulds for casting, to resist the penetrating action of the melted iron on the sand. Blacking is dusted over the surface of the mould, pressed down on it, and smoothed in the case of green sand castings; but it is mixed with clay water for covering loam mouldings. Its infusibility is its essential property as a protector of the sand.

BLAST FURNACE SLAG. See Slag, *Blast Furnace*.

BLASTING BY ELECTRICITY. See Electricity *for Blasting*.

BLEACHING POWDER. (Bleaching, vol. i. p. 362.) J. Herrenhoff—*Chemical News*, xxiii.—gives a new method for estimating the available chlorine in bleaching powder. It is founded on the fact that when bleaching powder is made to act upon an excess of stannous chloride in a strongly acid solution, stannic chloride is formed at the expense of the available chlorine in the former. The excess of stannous chloride is afterwards estimated by means of a standard solution of dichromate of potassium, and deducted from the amount originally employed. Graeger—*Dingl. polyt. J.*, cci.—gives the following process:—

To a dilute and strongly acidified solution of ferrous sulphate, the strength of which is exactly fixed by a $\frac{1}{10}$th permanganate of potash solution, the bleaching powder is added with a pipette, the point of it being placed close to the bottom of the vessel, so that the bleaching powder solution forms the lower layer of the liquid. The glass stopper is then placed in the bottle, which is well shaken, and then allowed to stand for some minutes. When a sufficient quantity of ferrous sulphate is used, scarcely any smell of chlorine is perceived on opening the bottle. The excess of the ferrous salt is now estimated with the $\frac{1}{10}$th permanganate solution, the difference between this and the original amount of ferrous salt used representing the weight oxidised by the hypochlorous acid, from which the available chlorine in the powder is readily calculated. See also *Comptes Rendus*, lxxv., and Watts's *Dictionary of Chemistry*.

Exports.

Bleaching materials	1874		1875	
	cwts.	£	cwts.	£
To Russia	40,193	20,490	53,130	31,810
" Germany	120,207	58,778	141,698	68,792
" Holland	25,476	13,844	30,690	15,098
" Belgium	37,843	19,581	49,353	23,042
" United States, Atlantic .	357,832	183,559	437,544	197,703
" " " Pacific . .	2,047	1,651	780	380
" Canada	14,544	7,708	12,242	5,761
" other Countries . . .	39,356	21,804	65,496	29,289
Total . . .	638,525	327,424	800,730	351,874

BLEGIOOLITE. An iron oolite, belonging to the brown Jurassic formation of the Alps, in the Canton Glarus. It is remarkable as containing the constituents of sea water, apparently proving that particles of sea water were mechanically enclosed in the mass when it was deposited.—Bættner, *Deut. Chem. Ges. Ber.*

BLENDE. (Vol. i. p. 397.) This mineral has been found at Unkel in rhombic dodecahedrons, sometimes of considerable size, and having their faces thickly covered with smaller blende crystals, all disposed parallel to one another.—Lasaulx, *Jarbuch f. Mineralogie.* See Zinc.

'BLEU DE LYONS.' To prepare this colour, 20 kilos. of crystalline rosaniline are introduced into boilers provided with agitators and heated in a bath of oil; from 4 to 8 kilos. of aniline, and about 10 per cent. of crystallised benzoic acid are then added. The whole is heated to 130° C.

To judge of the progress of the operation, the workman takes out a sample from time to time, and places it upon a plate beside a sample of the right colour. Alcohol is then dropped upon each sample, and, the plate being inclined, the colours of the solution can be easily compared.

When the operation is terminated, the mass must be quickly cooled. The thick mass is expelled by pressure of air from the vessel and received into the vat, when it is agitated with dilute hydrochloric acid, to remove the excess of aniline. The blue remaining insoluble is collected upon filters and washed. It is further purified by

alcohol or benzine, which dissolves out some red or violet impurities.—Wurtz and Poirrier.

'BLEU LUMIÈRE.' *Sky Blue.* The 'bleu de Lyons,' purified by hot alcohol and ammonia. The dyeing is performed in neutral liquors, and the blue developed by passing the goods through acid.

BLOOMERIES. Hearths similar to ordinary forges. See Iron Making *Direct from the Ores.*

BLOWPIPE. (Vol. i. p. 405.) See some useful blowpipe reactions, under the heads of the several metals. These have been chiefly derived from a paper by Professor E. J. Chapman, Ph., of University College, Toronto, published in the *Philosophical Magazine* for December 1876.

BLUE, COUPIER'S, is prepared, according to A. Wurtz, by heating in an enamelled iron pot—

Aniline, for red	38 parts
Nitrobenzine	17 to 20 ,,
Hydrochloric acid	18 to 22 ,,
Cast-iron turnings	2 ,,

The whole is heated above 180° C., and for 6 or 8 hours. The crude product is heated with 5 times its weight of sulphuric acid for 4 hours, commencing at a temperature of 50° C., and finishing at 90° C. Twelve kilos. of the crude material give about 60 kilos. of the sulpho-conjugate acid, which is precipitated by adding 400 kilos. of water. The blue precipitate is collected upon filters, and washed in water. It is employed for printing blacks and greys. The blue dye is dissolved in caustic soda, dried, and sold in small dry pieces of a blue black colour.—*Progrès de l'Industrie des Matières colorantes artificielles*, by A. Wurtz.

'BLUMIGE FLOSS.' A German term for fine grained pig iron. See Iron.

BONES. (Vol. i. p. 412.) See Phosphates, for the solubility of the phosphates of bone ash in water saturated with carbonic acid.

BOOTS AND SHOES, MANUFACTURE OF, BY MACHINERY.—The application of machinery and the sewing machine, to the manufacture of boots and shoes, in the varied forms and designs now employed in this important and widespread industry, is of comparatively recent date. It appears to have been in the United States of America that the sewing machine was originally invented. It is stated that about the year 1835 a Mr. Walter Hunt, of New York, introduced the lock stitch, made by two continuous threads; but for want of a suitable apparatus for securing the necessary tension it proved useless. In the year 1841 a machine was invented by Messrs. Newton and Archibald for tambouring the backs of gloves, and in the following year Mr. John Greenough, of the United States, patented a machine for applying the shoemaker's stitch from a single thread by means of the double-pointed needle, previously invented, in the year 1755, by a German named Weisenthal, the stitch employed being that known as the simple tacking or chain stitch; this was a step in advance. Again, in the year 1843, another variety of machine was invented and patented by a Mr. Bostwick, in which a running stitch was made by the application of two toothed wheels which, working together, crimped the material and pushed it against a stationary needle. Another and a most important advance was made when, in the year 1844, Messrs. Fisher and Gibbons, of Nottingham, invented their machine for embroidering, which, by means of a needle and shuttle, formed the lock stitch. This was subsequently adopted by Messrs. Grover and Baker, who initiated a practical sewing machine.

In all the early attempts at constructing a sewing machine the great aim of the inventors was to imitate as closely as possible the stitches made by hand, in which a single needle and thread is used, the needle having the eye at the opposite end to the point. Advancing to the year 1846, the machine of Mr. Elias Howe, which still bears his name, was patented in the United States; it was, however, in one respect defective, the feed motion not being continuous. However, in other respects the machine embodied all the best principles introduced into sewing machines at that time; indeed, it is generally regarded as the parent sewing machine, and is largely employed in England and foreign countries.

A few years later the first really practicable feed motion was invented by a Mr. Wickersham: he substituted for the baster plate formerly employed, a wheel with a broad roughened edge protruding slightly above the surface of the work table. The material was held down tightly on this surface by a pressure plate. The wheel was given an intermittent rotatory motion which carried on the material by friction with its roughened edge. The next improvement in the feed motion was that known as the four-motion feed, which consists of a flat serrated plate, working through an opening in the table with a horizontal and vertical motion.

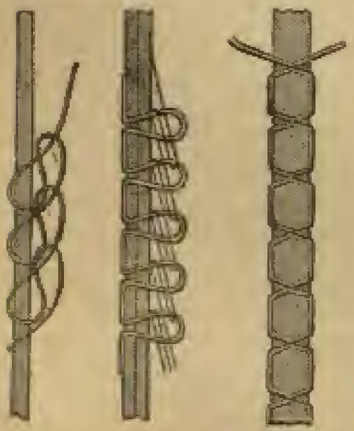
This four-motion feed was first applied to the GROVER and BAKER machine. It was an important improvement on the wheel feed, especially for all purposes of delicate or ornamental sewing, though the latter answers sufficiently well for heavy manufacturing purposes. In the wheel feed the needle works on one side of the feeding surface, while in the four-motion feed the needle can operate in the centre line of that surface.

In the Great Exhibition of the year 1851 but few examples of sewing machines were on view. One introduced by Mr. CHARLES HARLOW, described as a patent machine for uniting by stitches all kinds of woven goods, and useful in making articles of wearing apparel. In this machine two distinct stitches were used; one of which appears at the back, and the other at the front of the fabric, so that each stitch formed an independent fastening, while the seam thus produced was firm and regular. Another machine was also on view, simple in construction and, as described, suited to sewing either a circle, curve, or straight line, at the rate of 500 stitches per minute. In this machine two threads were used, one of which was carried by a shuttle, and the other from a reel on the top of the machine, which was passed through the material by the point of the needle, so that when it was withdrawn from the material both threads were locked together, forming a firm and durable stitch, previously referred to as the lock stitch. The Paris Exhibition of the year 1855 brought together a great variety of sewing machines, of many of which it is said they were so perfect that little or no material advance was at that time made. Subsequently, at the London Exhibition in the year 1862 at South Kensington, about fifty machines, embodying different mechanical arrangements, were shown. At this time in the United States of America, according to the published statistics of that country, there were in use no less than 300,000 sewing machines, of which 75,000 were in use in private families. The Paris Universal Exhibition of the year 1867 was well represented in sewing machines of various kinds—37 in all. Of this number France contributed 27 varieties, the United States 21, Great Britain 12, the Principality of Hesse 2, and the Dominion of Canada 5.

The Stitch.—The principal stitches formed by the sewing machines in use are of three kinds: the lock stitch, the double-chain stitch, and the single-loop or chain stitch. The single-chain stitch has the property of being very easily unravelled, which for some kinds of work that may be required to be unpicked, is rather an advantage; but of course its use is not so general as that of the lock stitch (*fig.* 2213, *a*).

2213

a *b* *c*



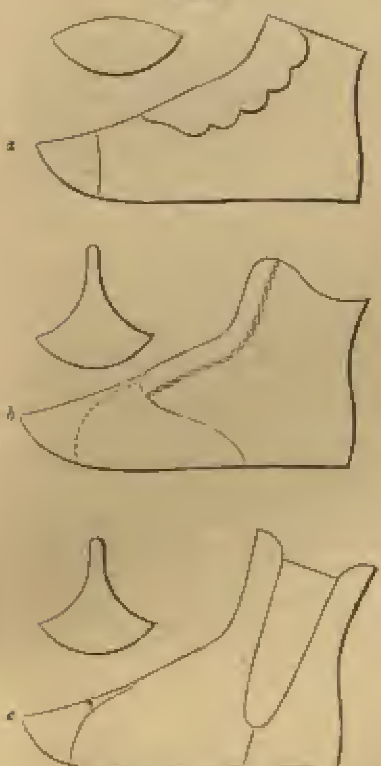
The chain stitch is that chiefly used for sewing the soles of boots and shoes. In this heavy leather work a waxed thread, stout and strong, and suitably prepared, is required, and leather stitching machines are generally known as waxed thread machines. The stitch is formed in much the same manner as the crotchet stitch: a needle, with a hook at the point like the crotchet needle, is passed through the material, the thread placed in the hook; the hook is then withdrawn, carrying a loop of the thread through the material and through the previously formed loops, so as to interchain the several loops one with another (see *fig.* 2213, *b*).

The double-chain stitch is formed with two threads. The upper thread is carried by an eye-pointed needle, which is passed through the material as in the lock stitch machine, and also through a loop in the under thread, presented to it by the looper. The looper is of a curved form, having two eyes with a groove between them, in which the thread, supplied from a bobbin on the under side of the work table, lies; and then an open loop is always supplied to the needle, which passes on the inside of the head of the looper. During the descent of the needle the looper is withdrawn in a circular direction, leaving a loop of its thread round the needle and the loop of the needle thread, which is still tight, against the needle. As the needle is withdrawn, this loop, by the friction of the thread with the material, bulges out, and before the eye of the needle has ascended above the point of the looper, the latter returns and passes a loop of the under thread through the needle loop. This stitch (see *fig.* 2213, *c*) is chiefly used in embroidery. Many of

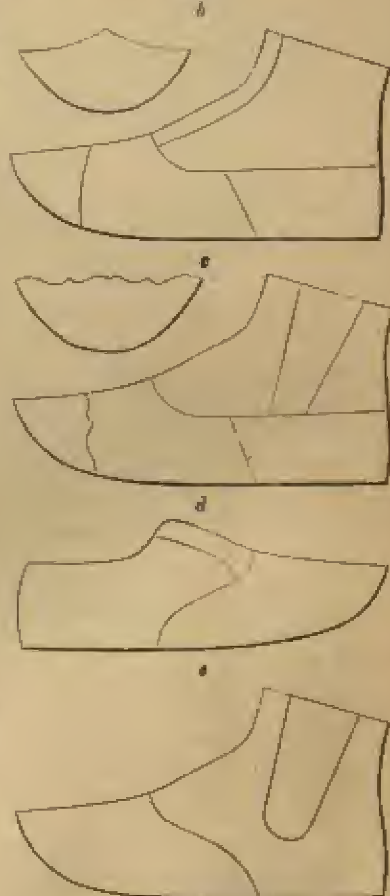
the facts contained in the foregoing general sketch of the sewing machine are drawn from Captain Hozier's *Report on Apparatus for Sewing in the Paris Exhibition of* 1867.

Preparation of the Uppers.—Nearly all are more or less familiar with the names of the different parts of a skin of leather, its character, and the general purposes to which applied; take, for example, a calf skin, the butts and ribs are the finest and best parts of the skin, and most suitable for taking a polish; the pithy part is that running from the tail to the neck, while that part of the skin in the region of the hip is more pliable and has a great tendency to stretch; the various parts of the skin are known as the butt, belly, rib, shoulder, and neck. The manner of cutting up a skin is greatly influenced by its character and quality, hence the importance of the cutter-out or 'clicker' having a thorough knowledge of his craft; with this knowledge he is enabled to select the prime portions of a skin for the fronts of boots and shoes, otherwise known as 'vamps'—always rejecting such portions of the skin as may contain flaws or imperfections, which are utilised for such other parts of the upper as may prove most

2214



2215



suitable; the experienced clicker is thus enabled to cut up a skin to the greatest possible advantage. *Fig.* 2214 shows a few examples of ladies' uppers.

a. Ladies' straight top button upper with straight toe cap. The parts are known as the leg, button piece, and toe cap.

b. Ladies' Victoria Balmoral, with vamp or toe cap, the latter indicated by dotted line, and with straight facing of white stitching. The parts are the vamp, or cap, and leg.

e. Ladies' Polish spring with toe cap. The parts are front and back, with gore in which is inserted and sewn elastic web.

Fig. 2215 illustrates a few varieties of men's uppers.

b. Balmoral upper, consisting of vamp and quarter, leg, facing (in which eyelets are inserted), and dotted line showing toe cap if used.

c. Side-spring upper, consisting of vamp, quarter, front and back part, gore for elastic web, and dotted line showing toe cap if used.

d. Lace shoe upper, consisting of vamp, quarter and facing for eyelet holes.

e. Spring upper, consisting of vamp, leg, and gore for elastic web.

Fig. 2216, Hunting upper, consisting of the parts known as leg, tongue, counter and back strap.

2216

Illustrations of the several varieties of uppers might be multiplied to any extent, the above patterns will, however, sufficiently illustrate their general form. They are made in endless variety of design and substance, according to the special purposes for which required, from the light pump or dancing slipper, to the elegant dress boot, and the more substantial fishing and heavy boot of the miner and navigator. With the application of machinery the process of preparing the various parts of the upper and lining is simple and ingenious. The shaping of the various parts being effected by a series of cutters, knives or punches of the required form and similar to those employed in cutting out dough for biscuits, but varying in form, as will be seen in the examples given above of the several parts of the lining and uppers.

The cutting of the parts of the upper is generally done by hand, it being desirable to select the best parts of the skin, which, as previously stated, is done by the 'clicker.' The linings of boots, however, when the manufacture is carried out on a large scale, is effected in a press, several folds of the required material being cut by one stroke of the knife. As the sole cutting machine is equally applicable to the cutting of the uppers and linings, it will be more convenient to refer to this machine when considering by-and-by the preparation of the sole leather for the soles of boots.

In some varieties of uppers, both ladies' and gentlemen's, the upper is cut in one piece; when this course of manufacture is followed, another step is necessary, namely, the shaping and forming of the upper; this is effected by a blocking machine, of which there are many varieties. The upper is doubled, and the bend for the instep given to it by pressure in the direction of a cross, so that a flat piece of leather cut to shape is converted into a well-formed upper adapted exactly to the form of the foot.

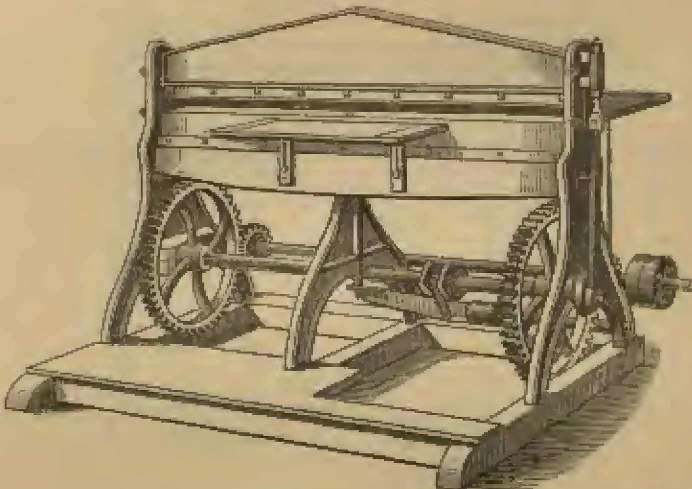
When the uppers are cut by hand the required patterns are made of stout paper, sheet zinc, or other material.

Preparation of the sole leather.—For the most part sole leather known as 'butts' is of considerable size and weight, and is tanned from the thickest and stoutest of hides. This process conducted by the tanner was formerly an operation requiring little short of twelve months; now-a-days, however, by a process known as the 'vacuum process,' the operation is effected within a period of three months, and even six weeks.

The 'butt' is first cut into long strips known as 'ranges,' of varying width according to the purposes for which required. *Fig.* 2217 illustrates a butt ranging, or as it is sometimes called a guillotine machine, the knife some 65 inches long. The machine

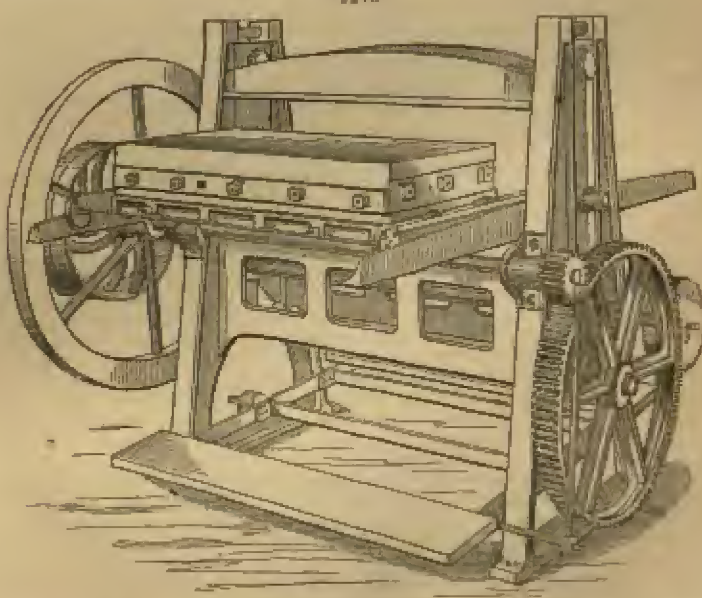
is driven by steam, and the necessary power to cut is attained by a multiple of gearing. On the outer ends of the counter shaft are cranks, these are attached to

2217



vertical rods, and connected to the sliding head to which the knife is fixed. The machine is provided with a wooden bed, and an adjustable gauge to regulate the width of the ranges.

2218

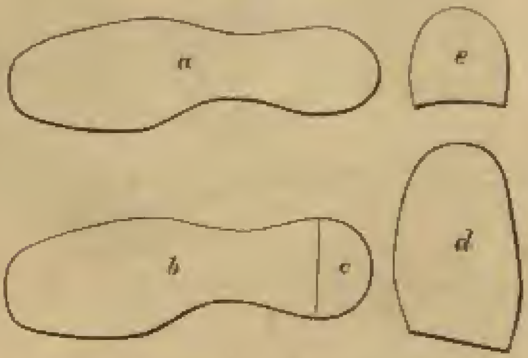


It is from these strips or ranges that the soles and half soles are subsequently cut, forming the next step in the manufacture. In the old system the soles and half soles were marked out on the sole leather, and skilfully cut by hand; now, however, as in

cutting the several parts of the uppers and linings, so also in the cutting up of the soles and heel pieces, a variety of steel cutters or knives are used, and are found to ensure great uniformity of pattern.

The preceding figure (2218) illustrates a press employed for cutting sole leather. It is provided with a rising running tray upon which the cutting board is secured; upon this tray is an arrangement of inclined planes, by which the cutting board is raised from time to time as its upper surface is worn away by the cutting of the knives; the table is carried by four rollers working on runners, this enables the operator to adjust his knife upon the sole leather; the tray is then pushed forward under the sliding head, which descends upon the knife, effecting the necessary cutting. *Fig.* 2219 shows in outline the several parts of the sole leather, namely, *a* the inner sole, *b* outer sole, *c* heel piece, *d* half clump or half sole, and *e* heel lift. As in the butt ranging machine the power required is attained by a multiple of gearing, the press being driven by steam.

2219



This machine is also made available for the cutting of uppers and linings; for the purpose of cutting linings, a supplementary tray is added, giving increased length, by this arrangement a long length of lining material, and of several folds in thickness, may be stretched out evenly on the cutting board and extended table for cutting, and is not disturbed by each cut of the knife, but the whole is carried backwards and forwards on the running tray, thus keeping the several folds of linings straight and even until the whole is cut up.

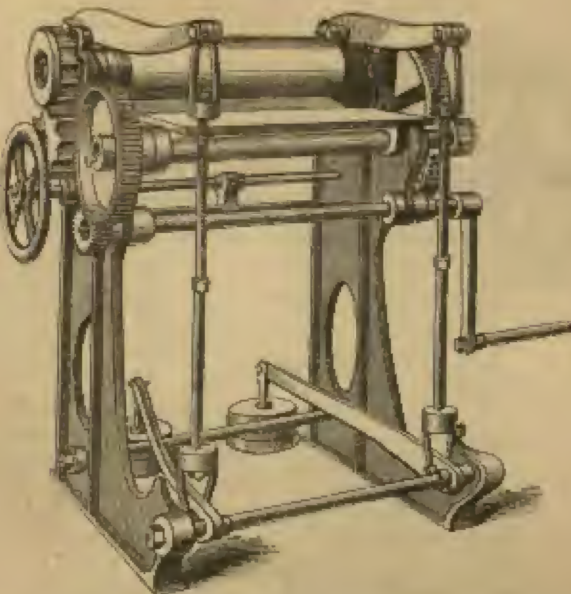
In machines of this description in this country it is the practice to run them continuously, the work being withdrawn from its action to enable the operator to place his knife. In the United States the practice is different; the action being intermittent, that is to say, the operator sets the machine in motion when he is prepared for a stroke, and when the stroke is made it stops automatically, until having placed his knife on the leather as he desires, he again puts it in action.

Toughening and hardening the sole leather.—Formerly the shoemaker's 'lapstone,' familiar to all, was universally employed for this purpose; by the process of hammering, slow and tedious, the sole was toughened and rendered more compact and durable in wear. Now, however, this toughening and hardening is efficiently attained by passing the long strips of sole leather or 'ranges' between rollers under great pressure before they are cut up into the various forms of sole and half sole previously referred to. The following illustration, *fig.* 2220, shows one of the various machines recently introduced; like others, it is constructed on a stout framework, and may be fixed to the floor or not at pleasure; an adjustment of movable weights on two levers seen below increases or diminishes the pressure, this arrangement prevents the possibility of injury to the rollers, through which the leather, however irregular in substance, is passed. The lower roller is raised or depressed by movable wedges, actuated by a shaft on which is a right and left hand screw, movement being given to it by a hand wheel.

In the old system of toughening the sole leather on the lapstone, it was previously soaked in water for a considerable time, and in the toughening of the ranges a similar course is in some cases adopted, they being soaked in water for twenty-four hours before being passed through the pressure rollers, after which they are laid aside to dry before being cut up into soles, half soles, or middle soles, as required. It may be

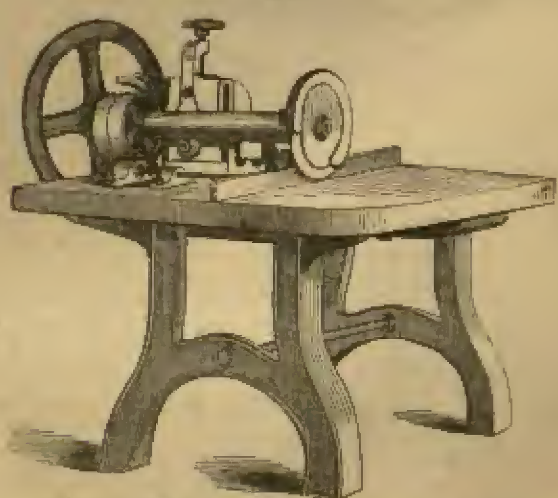
observed that the cutters or dies of steel, used in cutting out the sole leather, are commonly called 'sole knives.'

2220



Preparation of the Welts.—The means by which the upper is attached to the sole is by an intermediate strip of leather, known as the 'welt.' To one edge of the welt the upper and inner sole is sewn in the first place, and then the sole to the outer edge, the welt thus forming the connection between the two. The machines in use

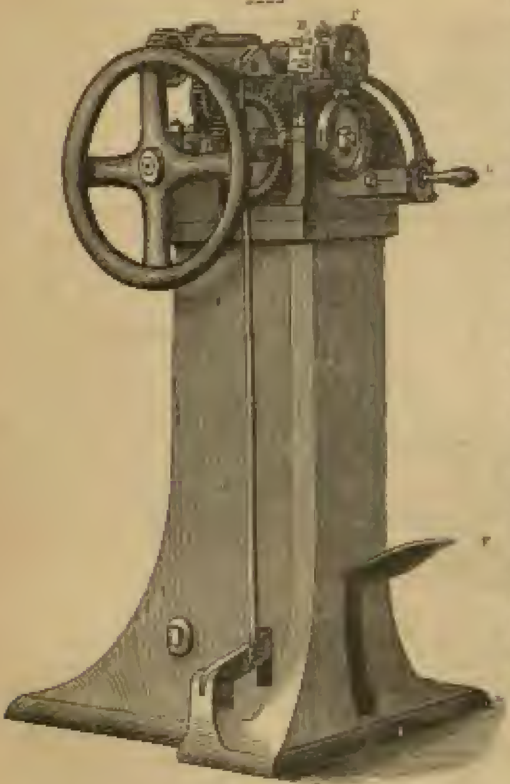
2221



for cutting welts and rands are various. *Fig.* 2221 is one used by the Crispin Company, of Newcastle-under-Lyme. The welts are cut by the sharp edge of a rapidly

revolving disc of steel which is protected by a guard, the width being regulated by a movable gauge upon the table. This machine is also used for cutting millbands, and is likely to be used for many similar purposes. The welts are next grooved and bevelled by a machine employed by the same company for this purpose. *Fig.* 2222, which is adaptable, by a change of cutters — also of steel and guide rollers—to channel the soles of all kinds of boots; by it heel rands are obliquely split, pump soles are bevelled and feathered — in fact, all the necessary cutting of the sole material has been 'died' or cut out, is effected so expeditiously and with such accuracy, that three of these machines, worked by boys, are found to produce work equivalent to the labour of twenty experienced workmen.

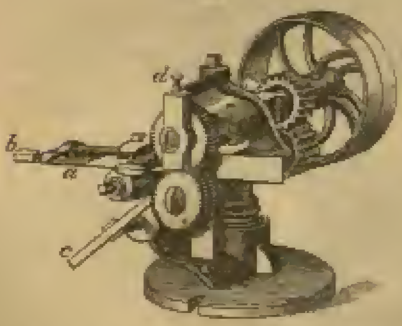
2222



The steel cutter, E, operates upon the sole or other material in course of preparation, placed between the feed and guide wheels, I and I′; the driving band is brought on to the speed pulley by the handle, H, and as the work is to be done by the feed wheels moving the material from right to left, the foot pressing on the foot lever, F, brings down the top feed wheel, I′; and all that is necessary for cutting to any suitable contour, is to hold the material up against the stop seen between the feed wheels. This machine produces perfectly regular work, and requires but little practice in its manipulation.

Another variety of machine, simple in construction, and introduced by the BLAKE and GOODYEAR COMPANY for cutting rands and welts, is seen in the annexed *fig.* 2223. In setting this machine to cut welts and rands, the knife *a* is adjusted by the setting screw *b*, just sufficient to allow the knife *c* to pass in front of the knife *a* against the presser foot, *d*. The knife *a* is adjusted by screws above and below the feed rolls. The set screw at the top of the machine is to adjust the distance between the rolls; that at the bottom, to regulate the tension of the spring.

2223

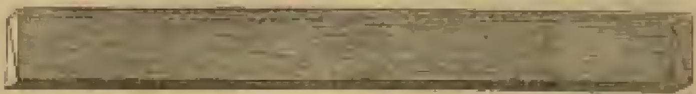


The pistol rand or welt cutter is another simple arrangement for cutting welts. The instrument consists of a stock, similar to that of a pistol, with a knife and guide plate, by which is arranged any width of welt or rand required. It is used by hand, and, being applied as desired, cuts the strips with accuracy and rapidity. To equalise the welt or rand in thickness by removing any inequalities that may exist, these strips of leather are passed through another machine, known as a 'chase skiver,' under

considerable pressure, the knife cutting the rand or welt to any substance, the pressure roller being adjustable to any gauge. The rand or welt is next pressed through another machine, in which a knife is suitably adjusted to bevel and groove the edges.

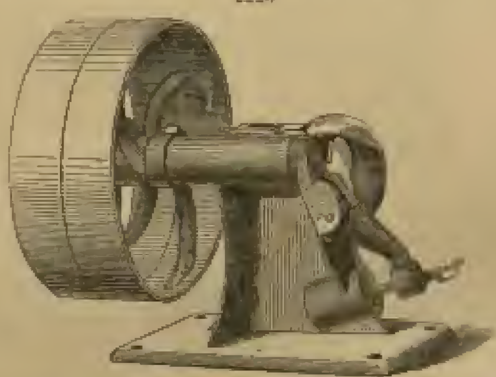
The splitting of the rands is also effected by the rand and welt cutter (*fig.* 2222), one knife cutting the rand to the width desired, the second cutting it obliquely; for this purpose the rand is carried on a guide plate, above which moves a serrated wheel, which serves as a feed motion, holding the rand firmly in position while the knives operate in the direction above described. In *fig.* 2224 the dotted lines indicate the

2224



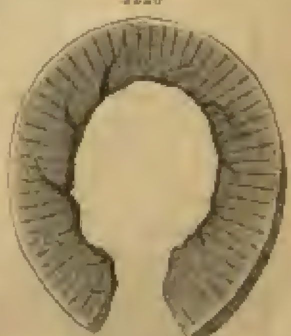
oblique direction in which the rands are split. These oblique cut pieces are subsequently used in the preparation of what is known to the shoemaker as a 'split lift,' the place assigned to which in the boot being the seat of the heel next the sole; and upon this split lift or lifts used is built any variety of heel required. The split lift is to make the heel seat concave, to suit the heel of the foot.

2225



In the preparation of split lifts a small machine is employed, known as a Rand-turning machine (*fig.* 2225). On the end of the driving spindle is fixed a steel rose head, with radiating angular grooves, and against which the rand, previously bevelled, is firmly pressed by a spring lever, and as the spindle is driven the rand is seized by the angular grooves in the rose head, carried round, and discharged from the machine duly formed, as seen in *fig.* 2226.

2226



In the best quality of work the heel pieces, or 'lifts,' are usually cut from sole leather, but in secondary and inferior qualities the top piece only, the intermediate lifts being cut from leather of a different quality.

The Closing of the Uppers.—The various parts of the upper, previously described, having been carefully fitted and adjusted according to the desired pattern and size, the next step in manufacture is called the 'closing,' which consists in the sewing or stitching together of the various parts into one called 'the upper.' Previous to the invention of the sewing machine, this operation was done by hand; in uppers of the highest class, hand labour is still employed, and will always hold its own. The sewing machines used in this branch of manufacture are extremely numerous and ingenious, and it would be no easy task to make a selection of those

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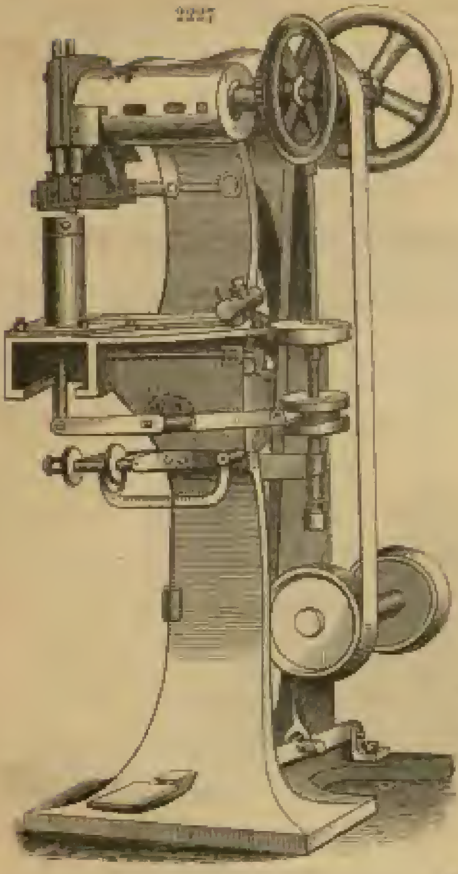
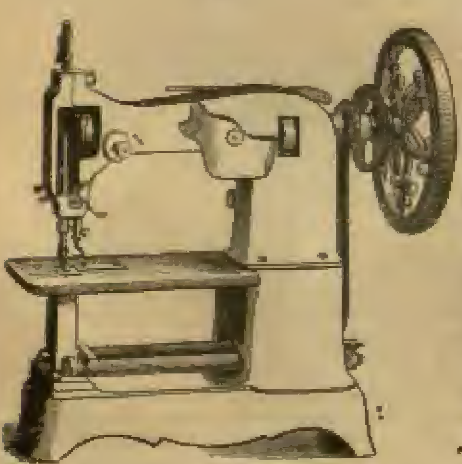


possessing the greatest merit. These machines are known as upper machines, and when heavy work is sewn, waxed thread machines. A description of two varieties will sufficiently illustrate their operation. The first (*fig.* 2227) shows the machine used by the CRISPIN COMPANY. In this machine ordinary waxed threads made of flax are employed. The sewing instrument pierces the material to be sewn without the thread, and after the first thread is seized, the second, or shuttle thread, is not drawn into the material until the awl is out of the work, and thereby draws sewing material into the hole made quite sufficiently to fill the hole tightly. Further on, when describing the welt and sole sewing machines of the CRISPIN COMPANY, the stitch employed, a combination of hook and shuttle, will be referred to and illustrated. Another variety of closing machine, that used by the BLAKE and GOODYEAR COMPANY, known as 'WHITTEMORE'S,' and using hard wax, is seen in *fig.* 2228. The stitch employed being the single loop or chain stitch, hard waxed thread specially prepared being used. It is used principally for sewing uppers of strong boots and shoes, and can be worked either by foot or steam power. A striking feature in this sewing machine is its oscillating head, which, when in operation, moves with each stitch made, and the length of the stitch. The piercing instrument is a straight awl, working in unison with a straight barbed needle, the awl working in front and in advance of the needle making the necessary holes for the sewing. The awl works from above, and the needle from below, consequently the loop or chain of the sewing thread appears on the back of the work. The bed of the machine is easily removed, should the nature of the work require it, and the adjustment screws are conveniently placed above the table on which the machine is fixed. The feed or stitch motion is a combination of awl and bottom, and is called 'awl and

2228



2229

2230

bottom feed motion. This machine has been at work for some years, and some 2,500 are now in use in the boot and shoe industries in England and the United States of America. The formation of the stitch is precisely the same as that employed in the BLAKE welt and sole stitching machines, and will be more fully described later on, when considering the sewing arrangements of the sole sewing machine of the above-mentioned Company. In the closing of those uppers where elastic web is inserted in the gores, another machine of lighter construction is employed.

Fig. 2229 (page 117) illustrates a few varieties of ladies' uppers:—

a. Ladies' Danish spring upper, with high vamp and toe cap.

b. Ladies' Danish imitation button, with high vamp and toe cap.

c. Ladies' Danish button upper, with high vamp.

d. Ladies' Victoria button upper, with toe cap.

e. Ladies' Victoria spring, with high vamp and toe cap.

f. Ladies' patent 'Period shoe,' with vamp and imitation toe cap.
g. Ladies' lace shoe, with high vamp and imitation toe cap
h. Ladies' 'Clyde upper,' with ornamental stitching.
Fig. 2230 illustrates a few varieties of gentlemen's uppers.
a. Calf imitation lace, with elastic side springs.
b. Calf military, with elastic side springs.
c. Calf Balmoral.
d. Calf button upper.
e. Calf open shooting upper.
f. Jockey upper with top.

Formerly it was the practice of the shoemaker to cut and prepare the uppers required in the course of trade. About the year 1850 it appears the 'ready closed upper' was initiated and commenced as a separate branch of the boot and shoe trade, and has in late years attained considerable dimensions, so much so, that in one of the earliest established firms in London—the Messrs. McCabe, of the City Road, who have furnished many of the foregoing illustrations—the shoemaker, knowing the size of the upper required for his boot, has a variety of from 1,200 to 1,300 different patterns to make a selection from.

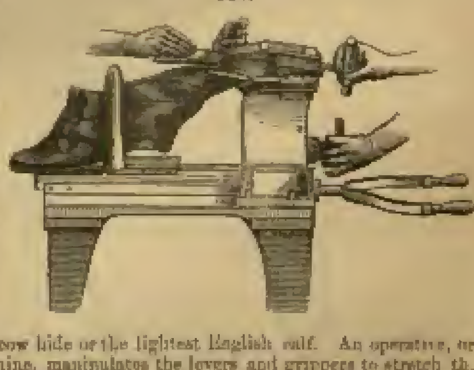
The Last.—One of the most important features connected with the manufacture of boots and shoes, whether by hand or machinery, is that the form of the boot or the shoe should have the same, or very nearly the same character, as the foot itself, and not only the same form, but that all its parts, namely, the heel, the toe, the bend of the great toe, the broad part of the foot, the waist, and the instep, should all have their true position, and these features are essential to comfort and freedom of action when it is borne in mind how admirably nature has suited the foot for balancing the body in its various movements.

A boot or shoe should fit easily, yet smoothly and comfortably, all over the foot, around the heel and ankle, as well as over the toe balls and instep. All boots must have some wrinkles at the joints; they need not occur of marked size elsewhere, and even there need not be so prominent as they sometimes appear. The lasts being carefully fitted and adjusted, a sure fit is secured, saving much discomfort to the wearer, and the avoidance of corns.

The manufacture of the last is in itself an important industry, its form and outline is, however, so well known that description is not necessary; it will be sufficient to observe that lasts were formerly made of wood alone, and by hand of late years machinery has been employed in their manufacture similar to that used in making gun stocks, and so minutely graduated that an accurate fit is always secured.

The Lasting of the Uppers.—As previously stated, lasts of wood were alone formerly employed. With the introduction of machinery iron lasts came into use. These like the wood lasts, are made in segments, easily put together, and as easily removed when the operation of lasting is completed. The closed upper is next placed on a last of a suitable size, as seen in the annexed *fig.* 2231 of a machine used by the Chapin Company. By the aid of this machine the toe is perfectly shaped. A regular pressure being applied instead of the uneven pulling and stretching by hand, all chance of unequal pressure on the toe is eliminated. Two operatives work this machine, and can efficiently last 150 pairs of men's boots in a working day, whether the material be the stoutest cow hide or the lightest English calf. An operative, on the right of the above machine, manipulates the levers and grippers to stretch the boot front by the left hand, and block the toe with the right. The second operative, on the left side, places the insole in the position the seam must occupy.

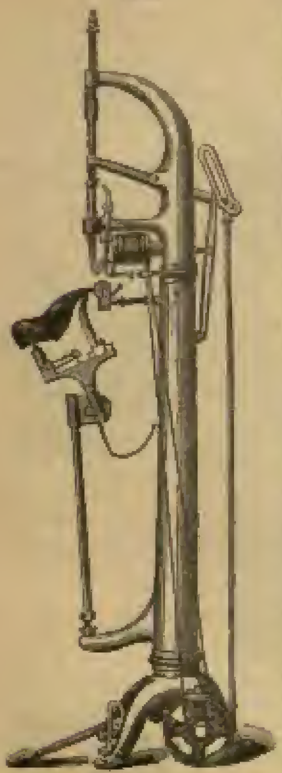
2231



In the ordinary system of lasting a very objectionable practice is followed, to a certain extent unavoidable, and that is, the operator making his mouth a receptacle for the tacks he is using, involving much loss of tacks from time to time by expectoration on the part of the operator, as well as danger in a sanitary point of view. Recently, however, a very ingenious machine has been introduced by the Blake

and GOODYEAR COMPANY previously referred to, known as 'The Magnetic Tacking Machine' (*fig.* 2232).

2232

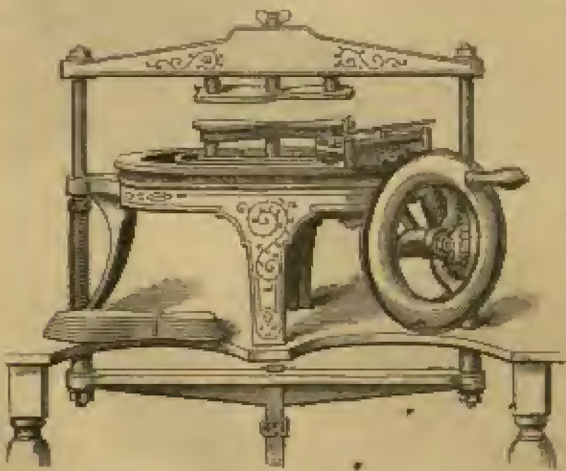


By this ingenious machine the objections above mentioned are obviated. The tacks are placed in a brass cylinder, in which is a brush that regulates them during the revolving, they falling heads up into a sliding groove or 'roadway,' down which they move one by one, when at each action of the operator the lowest one is taken up by a magnetic hammer and driven with one blow straight into the upper and insole at any place he desires. The machine has a universal swivel jack as holder, for the boot being lasted, and the tack driving hammer is worked by a treadle, thus allowing the operator the free use of both hands, enabling him to fit and draw the upper over the last, as is done by hand. In lasting a boot or shoe a certain amount of judgment is required, the upper varying in character and quality, rendering more straining necessary in one direction than another. The Tacking machine now referred to is manipulated with great rapidity, there being no loss of time, the hammer picking up the tacks or tingles at the rate of three in a second. There is no loss of tacks, each one being accounted for by the machine.

This tacking machine, when skilfully worked, can tack from 150 to 200 pairs a day, employing two operatives—the one to prepare the uppers for the last, and the other to do the necessary pulling of the upper and tacking by the magnetic hammer.

The succeeding stages of manufacture are—first, the preparation of the soles to be secured, and subsequently sewn to the 'uppers' by giving them the required bevel and outline; and secondly, by cutting the groove or channel in the sole to receive the stitches. The machine known as a rounding machine (*fig.* 2233), in which the soles are cut and shaped, the 'ranges' of sole leather, previously referred to, are passed between two templets seen above the bed plate of the machine, the lower one being permanently fixed, while the upper one is attached to the cross head, at each end of which is a side bar having a coiled spring

2233

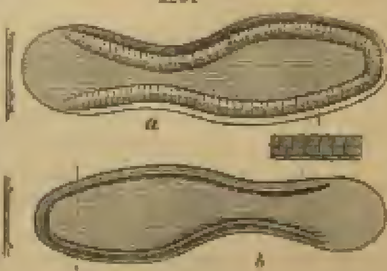


to secure the necessary pressure, this being obtained by the operator placing his foot on the lever treadle, bringing down the upper templet, and holding firmly the sole while it is being cut and rounded to the desired pattern.

On the bed plate, and around the templets, travels a carriage, to which is attached a knife, with sufficient play room to allow of its cutting the sole in the waist or narrow part, giving bevel to edge or square edge. The carriage carrying the knife, traverses the bed plate, the necessary power being derived by suitable wheel gearing situated beneath the bed plate, and put in motion by the power wheel worked by hand. The machine will round soles of any desired pattern at the rate of 100 pairs per hour. These rounding machines are more particularly adapted to those establishments in which a great variety of styles and sizes are manufactured; as they do not render necessary the use of costly steel dies and presses.

The operation following the rounding of the soles is that in which the groove or channel is cut to receive the stitches—a step requiring uniformity and precision—which is secured by the soles, in-sole and out-sole, being cut by dies or patterns previously described, so that they will be uniform. This will be understood when it is stated that the channelling machine always cuts the channel at a uniform distance from the edge of the sole: this distance is regulated by a gauge, so that broad or narrow channels may be cut to suit the various kinds of work. If the soles are not all cut alike, the channel, and consequently the seam, will come at different distances from the edge of the 'last,' causing an imperfect finish to the bottom of the boot when sewn. The channelling machine now referred to is that of the BLAKE and GOODYEAR COMPANY: it is attached to a work bench or counter, with suitable gear motion, worked by hand; it consists of a light framework some 12 ins. long; in the upper part are 2 horizontal spindles; at one end of the upper spindle is fixed a feed wheel notched in the circumference; beneath and at the end of the lower spindle is fixed a brass drum, having a smooth surface, serving as a guide wheel. An intermediate lever between the spindles above referred to, and put in motion by the treadle, has the effect of separating the drum from the feed wheel, thus giving the necessary space for the insertion of the sole, of any thickness required. The knives are fixed, one vertically to the framing above the brass drum, and the other laterally at the side, the former cutting the channel, and the latter feathering the edge of the sole.

2234



2235

The sole being inserted between the drum and the feed wheel, the treadle is liberated, and the sole firmly held in position and carried, or rather pushed, against the knives by the operator, thus effecting the channelling and feathering, as shown in *fig.* 2234.

a. Shows a sole channelled, and in which the stitches appear in a part of the sole as sewn by the BLAKE sole sewing machine, with enlarged view of stitch.

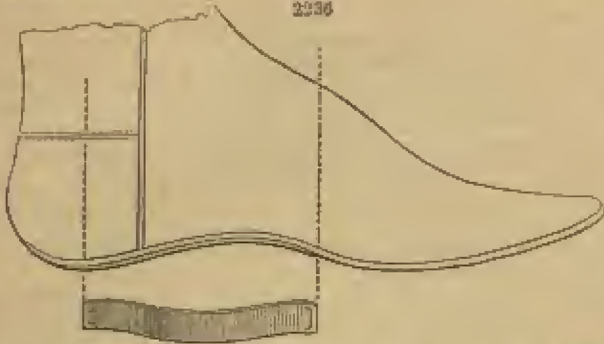
b. Shows an inner sole channelled and feathered for the welt sewing machine.

The sole, having been thus prepared, and moulded by another machine, to the form of the foot, is now taken in hand by the laster, who secures it by a few tacks to the 'upper' already lasted to the in-sole, by an ingenious machine which uses a tack comb (*fig.* 2235). The machine consists of a knife and hammer working in unison—the knife cutting the tack from the comb, while the hammer drives it into the sole, which it tacks in the required position. It is then taken in hand by another operator, who opens up the lip of the channel. The last is now removed from the boot, and the work is ready for the sewing machine. It is well to observe that at this stage soleing divides itself into two parts—the one heavy and light makes, usually called welting or double soles, the other pump or single soles. To sew these varieties expeditiously two kinds of machine are employed—the one a 'sew round,' and the other a 'sole sewing' machine, which will be described later on.

For some years past—in the manufacture of a superior class of work one variety may be referred to, known as the 'Flexura boot'—steel springs have been used. The spring, in the case of fashionable boots, imparts to the boot that property of retaining its shapely appearance after having been worn for some time, that it was the object of

the Fleuron to secure, and which is held in some esteem by lady wearers: of the springs thus employed the accompanying sketch (*fig.* 2236) is a variety known as the 'GOODYEAR steel spring.'

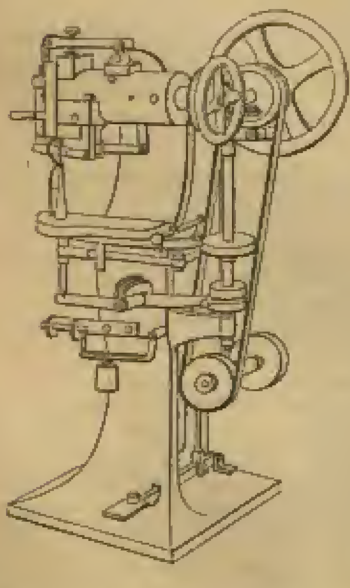
2236



The form of spring is intended to suit the curve of the waist to right and left boots, its place is between the inner and outer sole in the waist of the boot, the flat end of the spring being placed well under the heel, and pegged or nailed down through the holes into the in-sole at the heel only.

The Sewing of the Welts to the Upper.—The upper being lasted, the next stage in the case of welted boots is the sewing of the welts to the upper and in-sole. A variety of machines are employed in the shoe trade for this purpose; one or two illustrations will show how this is effected. In the welt sewing machine (*fig.* 2237) appears one very similar in construction to the upper and sole sewing machine of the same Company, in which two waxed threads are employed, producing what is known as the 'Crispin Tied

2237



2238

Stitch,' which will be fully described when considering the sole sewing machine. One of the threads is seen on the spooler below, under the sewing apparatus or hook, the other, or shuttle thread, above; each stitch being tied or locked, the object being to

imitate hand work as closely as possible in the sewing of boots and shoes. Another variety of machine, manufactured by the BLAKE and GOODYEAR COMPANY, appears in the illustration (*fig.* 2238).

The welt machine consists of a series of grooved cams, actuating a series of vertical levers; one of these gives the chain stitch round the needle; the needle is curved, and barbed, and radiating from a centre, which derives its motion from a toothed quadrant. The awl is actuated in a similar manner, piercing the hole obliquely through the sole, and being followed up by the needle. Another lever serves as the feed: on the end of this is a pressure foot; this pressure foot works on the channel of the inner sole, and also acts as the guide and feed during the sewing of the welt.

The apparatus above described is fixed on a standard frame worked by a treadle, and connected to the fly wheel by a rod on one end of the cam shaft, and a counter or register on the other end, by which is recorded the number of stitches made by the machine, and by which the manufacturer can check the amount of work done by the operative.

At the back of the machine and near the top is a spooler, upon which is rolled specially prepared waxed thread, which is carried over a series of pulleys to the looper, the necessary tension being given to one of the above pulleys by a coiled spring pressing against it, and regulating it by a small hand wheel. The tension on the thread in the machine is equal to a strain varying from about 12 to 16 lb., and in its passage from the spooler to the looper is kept in a soft and pliable condition by a jet of gas burning inside the standard of the machine. In the front of the machine is seen a rest or jack, upon which the last is placed, with the boot or shoe upon it, having a swivel motion, enabling the operator to bring it in contact with the sewing apparatus above.

It only remains to add that the work lasted for this machine is now done by hand, the inner sole being channelled and sewn to the upper and welt, after which it is returned to the laster, who removes the tingles or pegs which secured the upper to the inner sole and last; the outer sole, having been duly channelled and tacked on, is now ready for another machine, to be subsequently referred to, namely, the stitching machine. The channel in the outer sole, it should be stated, is not required to be deeper than in hand sewn work.

The Sewing of the Sole to the Upper.—The earliest adaptation of the sewing machine to the stitching of the soles to the uppers was the invention of Mr. LYMAN R. BLAKE of Abingdon, Massachusetts, U.S., and was patented and introduced into this country in the year 1859. The method relates to that part of the manufacture of boots and shoes wherein the soles are sewn or united to the vamps or uppers, and is thus referred to:—Hitherto the vamps and soles of those boots and shoes which are stitched have been united by sewing with the hand, a welt being sewn to the vamp or inner sole; then by stitching (also by hand) the outer sole to this welt, or the vamp and outer sole have been directly stitched together without the medium of a welt: other methods, slightly varied from these, have also been adopted. All these methods, however, are carried out by the direct and intermediate action of the hand, and all of them necessitate drawing the ends the whole length of the unused thread through the materials united at each successive stitch, which process renders necessary frequent

2239

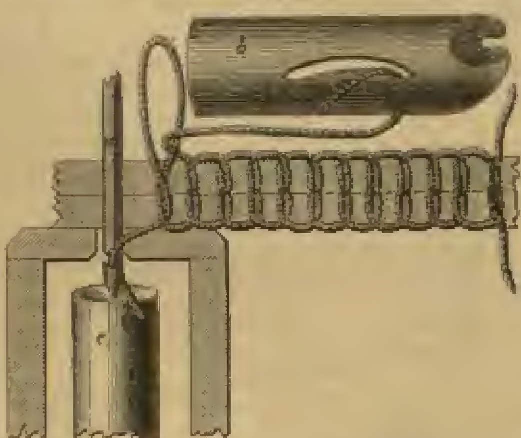
waxing of the thread, and consequent waste of time. In this invention of Mr. L. R. BLAKE, a sewing machine was first substituted for hand labour; the mechanism

employed in effecting this consists of an apparatus, which operates with a hook or crotchet needle, which pierces the inner and outer soles and vamps from without the boot or shoe (the last being removed), and unites the said parts by a seam formed by interlacing loops of the same thread, without drawing the end or ends, and the unused length of the thread, through the parts every time a stitch is formed, as in the case with hand sewing. The sole may be channelled upon the outside, so that in sewing the chain or interlocking of the loops is drawn into the groove, which covers it from sight, while the plain side of the seam comes within the shoe against the foot, the sewing being of the description which is usually known as the chain or tambour stitch. *Fig.* 2239 A represents a shoe made, and embodying Mr. Lyman R. Blake's invention of the year 1859, as it appears after the sole *a* has been sewn to the vamp *b*, and the channel closed over the stitching, as represented at the side of the figure. In *fig.* 2239 B the inner sole is represented by *c*, the lining by the dotted line, and the channel by *d*. *Fig.* 2239 C shows a vertical longitudinal section through the seam, showing the stitches.

Previously a system had been introduced by a French inventor by which boots and shoes were produced at a cheap rate, the soles being secured to the uppers by brass screws; the machine for this purpose was very ingenious, but its cost, slow work, and complicated character operated against its being generally adopted: eventually brass and iron nails were substituted for screws, and lasts made of cast iron were employed, so as to turn the points of the nails. Boots and shoes made on this system came to be known in the trade as 'rivetted boots'; and, owing to the low price at which they could be sold,—which was due in a great measure to the employment of boys and unskilled labour in their manufacture—a large trade arose in these goods; and to a great extent they superseded the welt sewn boots, which require labour of a more skilled and expensive character for their production. The defects of rivetted boots in time became apparent. The rigidity of the metal screws and nails destroyed the elasticity of the boot, and caused discomfort and sometimes pain in walking. The continual pressure of the foot and the wearing away of the leather forced the screws and nails inwards, so that they soon protruded on the inside of the sole, wore holes in the stockings, and injured the feet.

From this period, when Mr. Lyman R. Blake, in 1859, initiated the manufacture of boots and shoes by machinery, considerable progress has been made and great perfection secured. It is not, however, practicable, in the limits of this article, to describe in detail the numerous inventions contributing to this successful development.

2240

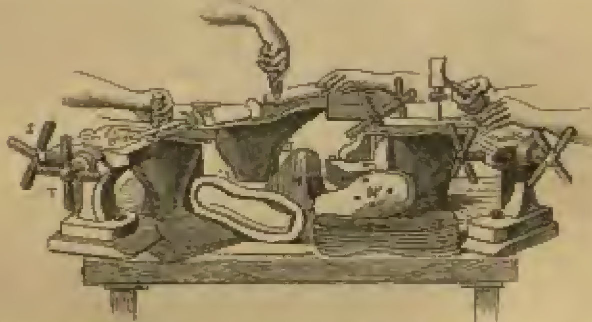


Advancing to the year 1863, it appears that Messrs. Keats took out their first patents in this industry, their object being, to use their own words, 'to secure with two threads, capable of being used when waxed with shoemaker's wax, seams which could not be made sufficiently solid by the ordinary sewing machine, which does not admit of the use of shoemaker's wax.' In the second place they desired to manufacture by machinery welt-sewn boots which should be equal in quality to the best hand-sewn boots, and at a price approaching that of rivetted boots. The stitch employed by the Messrs. Keats is known as the 'Crispin Tied Stitch,' and is a combination of hook and shuttle, as shown in *fig.* 2240. The sewing hook is indicated by *a*,

the shuttle by *b*, and the thread pinion by *c*. The advantages of this arrangement are stated to be twofold: first, the thread, not having to pass through an eye, can be thoroughly saturated with the wax, which is neither squeezed out nor scraped off by the barb; and secondly, as the hook in descending has no thread in it while piercing the leather, the hole made is no larger than the size of the hook, and a thicker thread can be used so as to fill the hole with thread and wax. Thus the leather is pierced by a steel instrument as in hand work, without the necessity of carrying a thread with it, when the double thread is subsequently put through the hole, the space is entirely filled up again, and by the tendency of the displaced particles of leather to regain their position, the same solidity is secured as in hand work. The hook draws up, as it ascends after piercing, the thread supplied by an intermittent thread guide from the bobbin below, and the shuttle above introduces into the loop thus formed the upper thread, while the hook is freed from thread by the lateral motion of the feeder, and is driven down again to pierce another hole and draw up another stitch from the lower thread. A partial turn of the under thread guide produces a twist in the stitch, the thread employed being specially prepared, and known as a cable-laid thread, possessing considerable strength and tenacity. The thread is waxed, the wax being kept warm by jets of gas, so that no rigidity interposes to prevent a proper tightening of the stitches.

In the next step of manufacture, as adopted in the works of Messrs. Keats—the welts having been stitched to the uppers—is a stage called 'shanking,' 'filling,' 'rounding,' and 'placing.' These several operations are effected by a 'contour machine,' which is shown in the annexed *fig.* 2241. Here a set of steel plates, cut out

2241

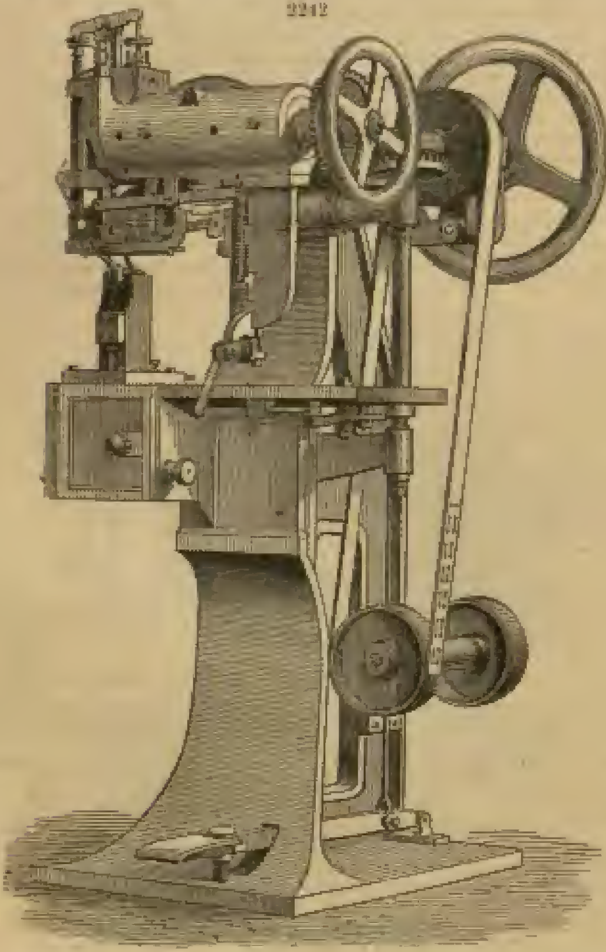


to the contour of any shaped boot as required after the in-seam is sewn, are bent to the contour of the last on which the boot is being made, and are hinged at the heel, the joint of the hinge being a rule joint. One side of the plates open out sideways by this lateral movement. There is room left for the boot to be inserted heel foremost, and with the sole uppermost; the boot is then secured to its position by the lever and screw, S, and the toe is held by a block corresponding with the toe block of the lasting machine. This block is forced up to its position by the screw, T, and the boot is then held so that the operator on the left hand can fill in the shank and space of bottom between the welt seams, so that the proper work of preparing strictly to the contour required is easily effected. The next operation is to place on the middle sole. This is done by an operator in the centre, after which the sole is placed on and tacked ready for stitching, which is done by an operator on the right hand. In all these operations with the contour machine female labour is employed. The boot is now removed, and is ready for stitching the sole on, as shown at *x* and *x'*. The next step is stitching the soles above described to the welts. This is effected by the same firm by a machine called the 'Heavy Sole Sewing Machine,' *fig.* 2242, the construction of which is very similar to others previously described, in which the Crispin tied stitch is employed; its construction, however, is of a much more substantial character, from the heavier nature of the work which it executes. Soles nearly an inch thick, of miners' and navigators' boots, are perforated with the greatest facility, the stitching being executed with much regularity and precision. This machine, like others of the same Company, is put in motion by slight pressure upon a treadle, which works an ingenious friction-clutch with very good effect.

The boot thus made and above described presents a somewhat distorted appearance, owing to the sole stitching having pulled away the welt from the upper. A powerful press (*fig.* 2243) is now brought into requisition, by which the sole is squeezed into

shape, and the boot is adapted more accurately to the form of the last. This press is also used for pressing heels into shape. It has on the under-side of its table a piston rod and lever so mounted, that after the heels are pressed into suitable form and substance in the die or mould, M (*fig.* 2243), by pressing on the foot lever the false die or bottom is lifted up, and the compressed heel, being made to the requisite form, is lifted out. The die or mould is made about seven inches deep, in a block of cast iron, the sides of the mould having different bevels or inclines suited to different forms of heels. The lower face of the heel is determined as to the shape by the blocks, which

2242

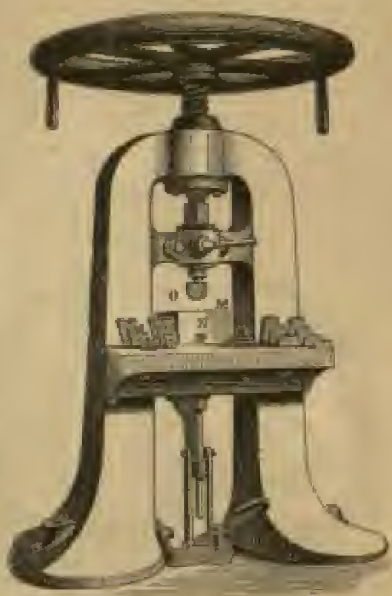


are held in the dies by the screw, N. These blocks are shown on the left hand, on the table of the press. The blocks on the right represent the different forms of plungers, and it will be seen by the lower end of plunger, O, that a convex surface is left so as to press the heel, to suit the heel of the foot.

Following the course of manufacture carried out by the Messrs. Keats, the further processes are thus described. A little paring and finishing, including the addition of nails, iron heels, tips, &c., for heavy boots, which are smoothed by Bessemer's emery stone wheels, is all that is now necessary. An upright work-bench (*fig.* 2244) is employed to aid in these finishing operations. This is an apparatus for holding the boot in a similar position to that in which the shoemaker formerly held the boot on his knee. There are two cylindrical forms of cast iron, one fitting inside the other: the upper one supporting the cradle for the boot to rest in, and with holes for the

iron heel peg; the lower one, which by its upper flange is screwed to the table, and carries the brackets at its lower end to hold the lever and stirrup on one side, and the rack on the other. As the stirrup is held by a swivel joint, it will be seen the boot can be turned to any angle while being securely held by the stirrup. This bench has been found more conducive to the health of the shoemaker than anything as yet introduced as aid to the trade since boots have been made on the factory system, and the work is held with such firmness, that it is perfectly easy for girls to do work that was formerly considered only fit for men. The heavier description of boots have been chiefly referred to in manufacture by the Crispin Company; every variety of foot covering is however, manufactured in the same works, from light pump sole slippers—which are sewn at the rate of one pair per minute—to the navvy's boots, a pair of which is completely sewn in 26 minutes.

2243



The Messrs. Keats and Clarke, whose boot and shoe machinery is above described as the Crispin Company, have recently secured a prolongation of their patent for a period of seven years. The original patent was granted in the year 1863; it appears, however, from the statement of facts made before the Judicial Committee of the Privy Council, that the invention was one of great public utility, costing them years of arduous labour, as well as heavy expenditure to secure perfection; further, that as in other cases its introduction was the cause of violent opposition on the part of the work-people, owing to certain tools being superseded by it. One of the inventors, Mr. Keats, was stoned through the village, and he had ultimately to remove his factory. The patentees further contended that the invention was at length likely to become remunerative to them, that hitherto it had yielded no adequate profit, and that upon a prolongation of the term a French and American patent also depended. On these grounds, their Lordships of the Privy Council granted an extension of the patent for seven years.

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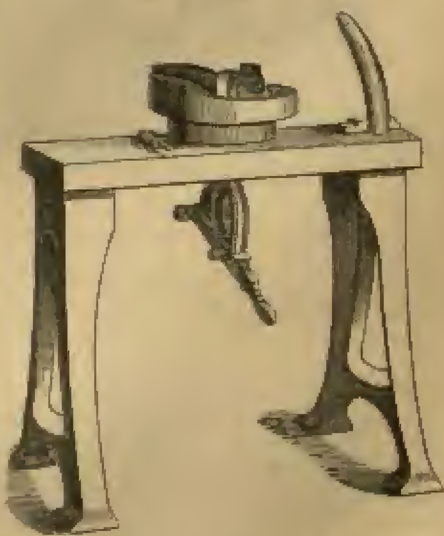
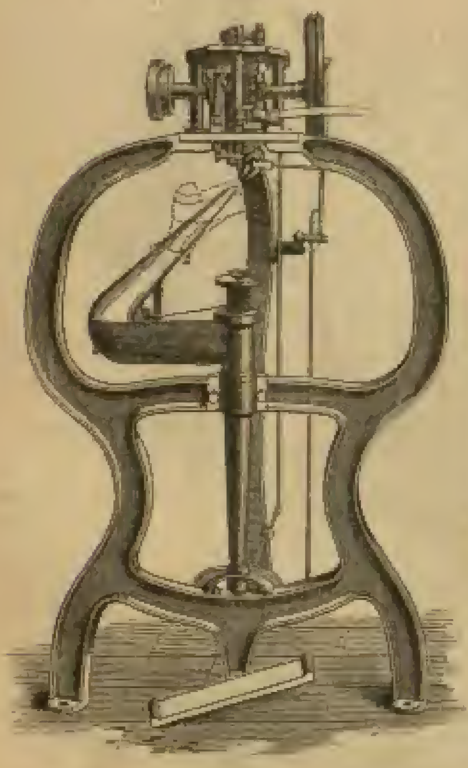


Already the process of manufacture carried out by the Crispin Company has been followed through its various stages; other processes in the manufacture of shoes by machinery are employed, possessing various degrees of excellence; it is not possible, however, in such a wide-spread industry and within the limits of an article to describe all

the varieties of machines employed. The system of manufacture, however, as carried out by the machinery of the BLAKE and GOODYEAR Boot and SHOE MACHINERY COMPANY, so complete in all its details, and which has already been followed to the lasting of the upper by the magnetic tacking machine, and the tacking on of the sole, previously bevelled and channelled, and ready for the sewing machine, that it is desirable to follow the subsequent branches of manufacture in the order in which they occur. The sole sewing machine of the above-named Company is now brought into requisition. The annexed figures (2245 and 2246) exhibit a front and side view of this machine.

2245



Upon the movable arm or horn, which has a lateral circular motion, is seen the boot, placed in position to be sewn, and on the top of the spindle which carries this horn, and on which it revolves, is a drum or spool, on which is coiled sufficient waxed thread, suitably prepared, for sewing 150 pairs of boots. A coiled spring regulates the tension of the thread, which, on a certain kind of heavy work, is equal to 30 lb.; while a self-acting throw, with which the machine is provided, has the effect of making the stitch alike with equal tension, whether the sole is thin in the waist or thick in the fore part of the boot. The waxed thread is kept in a pliable condition while the sewing is in progress by a small jet of gas contained in a chamber within the horn, in which is a receptacle through which the gas passes — formerly a spirit lamp was used for the purpose. In the tip of the horn is a small wheel called the 'whirl'; in this is a thread hole, through which the thread passes from the spooler under a small guide wheel through the horn to the tip, ready to be taken up by the hook of the sewing apparatus above.

The stitch employed is the single chain or loop stitch, seen in outline with the sewing apparatus in *fig.* 2247.

To the right of the needle or sewing hook, and between it and the feed point, is an ingenious contrivance—a 'cast off'—working in connection with the needle, with which it moves downwards until it touches the surface of the leather, and rests there while the needle goes down and takes the thread in the whirl at the tip of the horn, and comes up through the sole. During the descent of the needle through the centre of the 'whirl' already referred to, the 'whirl' makes a partial revolution, carrying the thread with it, the effect of which is to throw the thread into the barb of the needle. Again, while the needle is completing its downward stroke, the 'cast off' has a motion imparted to it which allows it to cover the hook of the needle during its upward motion, after leaving the surface of the leather.

The other parts of the sewing apparatus are the feeder and pressure foot; the former, in its downward motion to enter the leather, slides in contact with the pressure foot, and as the feeder always feeds to the same point, at its extreme feeding movement the length of the stitch will be determined by the pressure foot, which to lengthen the stitch will be moved from the needle, and *vice versâ*. The feeder works in the channel of the sole, guiding its movement forward during the operation of sewing, while the pressure foot holds the work firmly in position.

In all these operations, to ensure good sewing, all the steps appertaining to preparing the shoe for sewing is indispensable. One of the most important is the channelling

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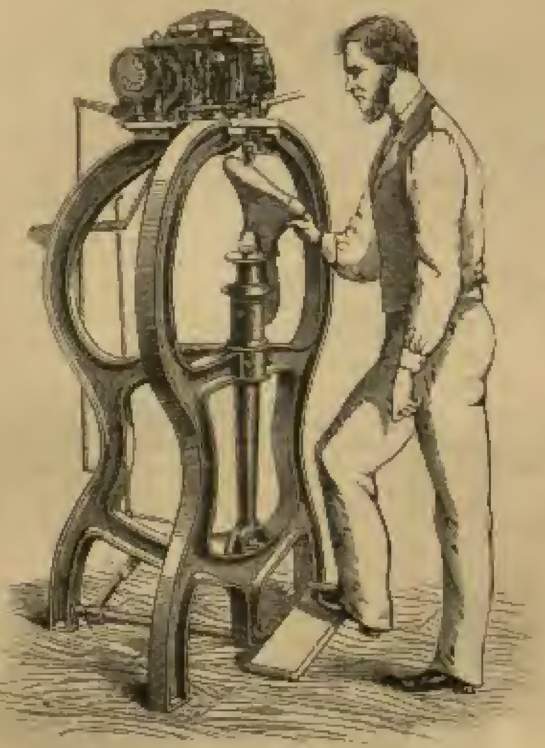
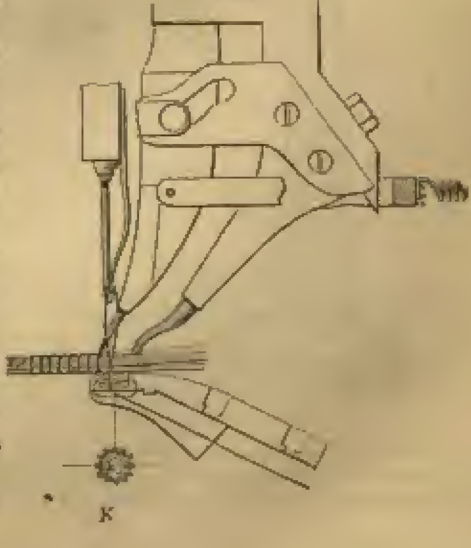


of the soles. The channel should be cut far enough from the edge of the sole, to allow room in the toe of the shoe for the tip of the horn to enter, and not bind the shoe in sewing round the toe, and the groove taken out for the loop of the stitch just enough to receive it, and not have the stitches show through the surface of the sole when finished.

It is also important that the out-sole be properly placed on the shoe in lasting, and securely held in position, because as the shoe on the horn is fed by the feed point acting on the upper surface of the channel, if the out-sole is not firmly held to the in-sole and upper, the out-sole will be pushed by the feed point in the direction that the feeder acts; and when the shoe is

2247



sewn, the sole will not come under the shoe, but project further on the side towards which the feeder acted in feeding.

In concluding these remarks in reference to the sewing of the soles, it may be mentioned that it is next to impossible for the most careless workman to make a mistake in sewing off the line of groove or channel; but it is easily remedied should such a mistake arise, by at once pulling out the waxed thread before it cools; and even in the most careful sewing, should the thread break, the stitching may be continued, as the wax holds the thread firmly in position as it cools, and experience shows that it does not in any way impair the stability or durability of the boot in wear.

The capacity of producing sewn boots by this sole sewing machine will be understood by the well ascertained fact that a skilful machinist will sew upwards of 300 pairs per day of 9 hours, at the rate of 3 dozen pairs per hour.

The use of this machine is very general at home and abroad, some 2,300 being in constant operation during the past year, sewing an aggregate total of 100,000,000 pairs of boots and shoes. The French Government employ it largely in the manufacture of shoes for the navy. The Austrian Government has 26 in operation, making boots for the army, while our own War Department gave out contracts in the year 1875 for 50,000 pairs, increased to 250,000 pairs during the past and present year, for the army and militia. For many years past the boots for the departments of the Post Office, and the Metropolitan Police, have been sewn by these machines, and it appears that during the Franco-German War a contract was entered into to produce 50,000 pairs of shoes in 60 days, which was duly fulfilled.

The original BLAKE sole sewing machine was introduced into the United Kingdom about the year 1860 or 1861; at that time it was a portable machine, with a fixed or stationary horn: the present machine with its revolving horn was introduced in the year 1864 (since which date many important improvements have been made), and is still in action in the establishment of the Messrs. POCOCK BROTHERS in the Southwark Bridge Road, London, with two others working side by side, and actuated by steam power.

2248

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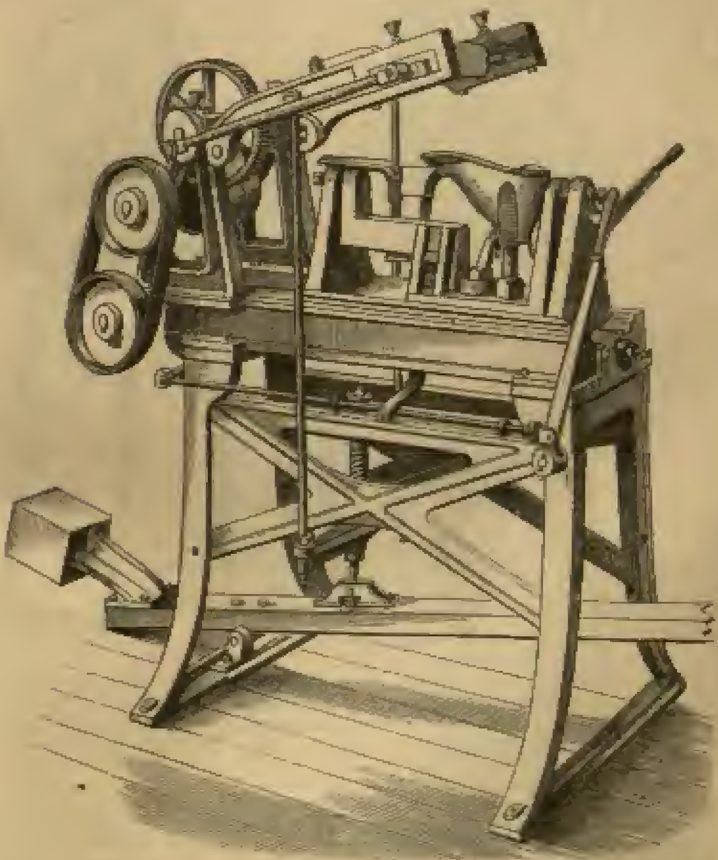
The rapid development of the above named sole sewing machine, in the manufacture of boots and shoes may be gathered from the following figures.—In the year 1862 the total number of pairs of boots and shoes sewn by the BLAKE machine was 200,000,

increasing to 15,000,000 in the year 1865, and 45,000,000 in the year 1870; while in the past year the production amounted to nearly 100,000,000 pairs of boots and shoes of all varieties sewn by the 2,300 machines in use throughout the globe.

The machine above referred to consists of nearly 300 pieces, each of which have a distinguishing number, and all the parts are made in duplicate; to the shoe manufacturer using the machine this is convenient, since, should any accident arise to any part by injury or otherwise, it is promptly replaced by a duplicate piece, thus enabling the manufacturer to resume operations with little loss of time.

The sole stitching machine (*fig.* 2248), made by the same Company, is similar in construction to the welt sewing machine already described; but instead of the jack used in that machine to hold the work, it is held by the hands of the operator, and pressed firmly against an adjustable guide fitting in the feather of the boot, as seen in *fig.* 2248. This machine, as previously stated, is worked in connection with the welt sewing machine already described.

2250



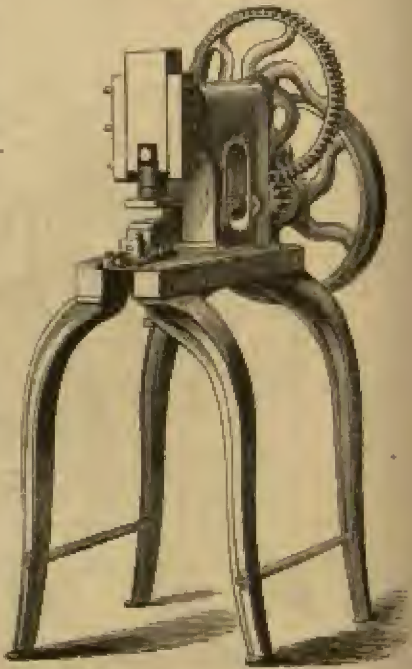
In the sewing of the lighter kinds of work another variety of machine is used, of a lighter construction, the sewing apparatus being on the same principle as that previously described in the sole sewing machine, and known as the 'Sew round machine' (*fig.* 2249), having the appearance of an ordinary sewing machine upon a metal standard. The chief point of difference between this and the sole sewing machine is, that there is of necessity no revolving arm or horn. In the preparation of the work for this machine the process is somewhat different, as both upper and sole are placed on the last inside out. The sole to be sewn being placed in position, a bender with a

lip to it, seen above, is inserted in the channel, which it keeps open while the awl makes a hole in advance of the needle, through which the stitch is carried by the needle: the piercer or awl making the hole for the needle comes from above; and the needle comes from below in place of from above, as in the sole sewing machine.

The last is retained in the boot while the sewing is being effected, the stitch having a diagonal direction in regard to upper and sole. After the boot is sewn it is returned to shape, having been lasted as previously stated inside out. This machine sews a lady's pump boot round in half a minute, using from 70 to 100 stitches. On this machine, as on others, an indicator is affixed, by which the number of stitches made are duly registered.

Sole Rolling.—The boot being sewn and the channel rubbed down, it is now taken to the sole rolling machine (*fig.* 2250), by which under great pressure any irregularities in the surface are rubbed out and the leather hardened. The operation is effected in the following manner: The boot is placed on a wood or iron last, fixed securely on an adjustable jack and locked by a ratchet motion. This swing jack has a transverse motion worked by a lever seen on the right, enabling the operator to adjust the boot to the required position under the roller, another lever appearing on the left with an intermitting motion secured by friction pullies moves the boot backwards and forward under the pressure roller. This arrangement enables the operator to roll any part of the sole and remove any irregularities occurring on the surface, the pressure being increased as required. The machine is generally run by steam power, and is in its action equally applicable to the soles of rivetted or pegged work, while the breaking of the stitches, which frequently happens in the old system of hammering the soles, is avoided.

2252



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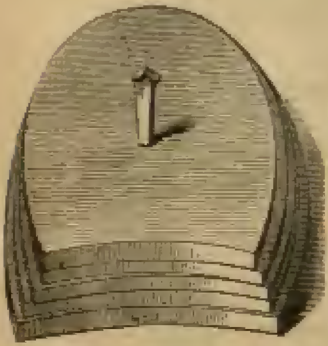


The previous operations described show the various stages of manufacture through which the boot has passed to the sewing on of the sole and the tacking on of the heel-piece; this is succeeded by the preparation and affixing of the heel. The heel is made up of a series of pieces of leather cut to various sizes and called 'lifts,' as seen in outline in *fig.* 2251; boys arrange these lifts and drive a single nail through the whole to keep them in place, while the subsequent operation of pricking the holes to receive the nails is effected.

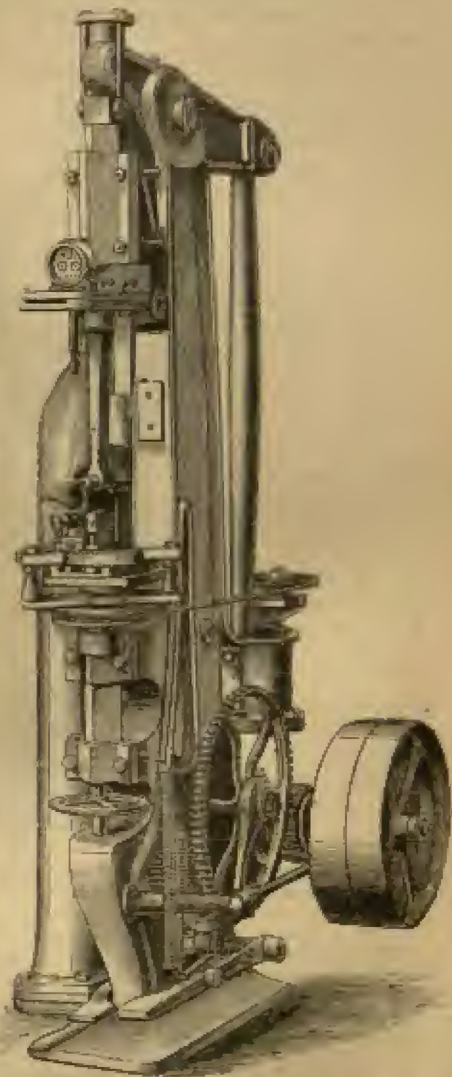
The heel pricking machine is now brought into requisition (see *fig.* 2252).

The rough heel is next adjusted to a plate the size of the top piece of the heel. This plate contains a number of holes, through which a corresponding number of awls are driven into the heel: the awls are either straight or curved, according to the form of the heel pierced. The holes made in the heel go completely through, and in these holes thus made are inserted nails of sufficient length to pass through the heel and

sole of the boot to be subsequently clenched on the inside of the boot against the iron last. Considerable pressure is required in this operation, the rough formed heel being firmly secured in a mould, into which is driven the awls from above through the top piece previously referred to.

The heels are now taken to a heeling machine, the nails are placed in the holes already prepared and secured there by a templet corresponding to the size of the top piece. To this templet is adjusted a number of drivers to act upon the nails when the fixing of the heel to the sole takes place.

2253



The boot upon which the heel is to be fixed is secured in position in the machine (*fig.* 2253). It is placed on an expanding iron last affixed to the pressure arm, which appears above. The arm carrying the boot is next pushed backwards, and is received by expanding clips, holding the boot at the seat firmly, and directly over the heel to which it is to be fixed. The operator now throws the machine into gear by a treadle, seen below on the right. In effect the heel is forced into its position, the necessary pressure driving the nails through the sole and clenching them inside the boot against the iron last.

Another operation carried out by this machine is the paring and trimming of the heel; a knife of the form required is attached. These knives are made of various shapes and depth, according to the height of the heel, and are fixed on a slide having a circular motion, which sweeps around the heel, shaving it to the required form, the motion imparted to the knife is obtained by depressing the treadle on the left, which communicates with gearing, and affords the necessary pressure to put the knife in motion, as above described.

A third treadle has the effect of throwing the locking apparatus out of gear and releasing the boot, which has been held firmly while the attaching and paring of the heel was being effected.

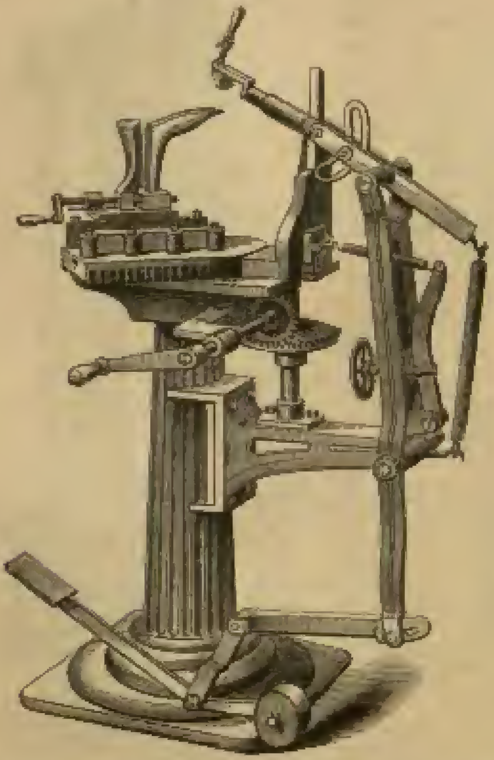
An edge paring machine now comes into operation, preparing the edges of the soles for finishing, as seen in *fig.* 2254.

The last upon which the boot to be pared is placed is made in two parts, with guide screws to raise and expand it. A carriage carrying the lasted boot traverses the bed plate in a manner similar to that of the knife in the rounding machine previously described. The edge of the bed plate being geared and worked by a pinion put in motion by the handle seen below, having the effect of bringing the edge of the sole round to the cutting instrument. The

knife may be set to cut any variety of sole, single, double, or clump. By the movement of the treadle, motion is imparted to the knife, which is brought down to the edge of the sole and there kept while the necessary cutting or paring is effected, the tension required being secured by coiled springs. The arm carrying the knife is so contrived, that any variety of knife may be inserted to suit the work the machine is paring.

Heel Burnishing.—Formerly the finish given to the heel was effected by the shoemaker using a composition known as 'heel ball.' This was melted by the aid of a tallow candle and well rubbed over the heel, after which the application of a hot iron gave the desired finish and polish. In *fig.* 2255 appears a machine employed for this purpose.

2254



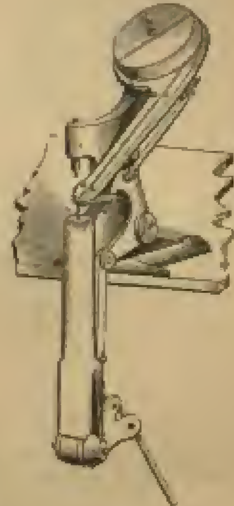
The boot is seen firmly fixed against a plate or templet of the same size and form as the top piece of the heel to be burnished. This plate is let into a slot made for its reception in the arm against which the heel is pressed, the object of this templet or heel plate being to protect the top piece of the heel from injury or disfigurement during the operation of burnishing. To the jack holding the boot is attached a rod with a lever and spring. This arrangement when pressed forces the boot into position and the heel is brought into contact with the burnisher which appears above. In the end of the burnishing iron is a receptacle, in which is arranged a jet of gas. This is kept burning during the working of the machine, the object being to maintain the necessary temperature in the burnishing iron. To the burnisher is adjusted a spring, which admits of its moving over the heel with regularity. The movement of the burnisher is semi-circular, from left to right and *vice versâ*, the motion being communicated by a rack and pinion, connected with an eccentric cam attached to the driving spindle.

The machine above described is worked by steam, and attended to by a boy, who can burnish from forty to fifty pairs of heels in the course of an hour. Ink being used to

black the heel instead of 'heel ball,' the ink when dry and ironed, as above described, produces a durable gloss. The only remaining stage of manufacture required, irrespective of the final ornamentation and hand papering of the soles, is cutting a clean face on the side of the heel next the waist of the boot. A knife is here used called a 'breasting knife,' and so adjusted in its upright frame that it is regulated to cut through the lifts to the waist of the boot, giving the end of the heel a clean face. Care must be taken in using the breasting knife, otherwise, if urged too far, the waist of the boot may be disfigured.

2255

2256



Eyeletting.—As in other branches of shoe manufacture formerly done by hand, so in the insertion of eyelets in those varieties of boots in which laces are used to secure the shoes or boots to the feet, the eyelets were inserted, and by a suitable pincers clenched and set firmly in position. Various machines have been used of late years for the insertion of the eyelets, simple in construction and effective in operation, in all however, it was necessary that the operator should place the eyelet on the nipple, subsequently clenching it on the leather.

The annexed *fig.* (2256) illustrates a self-feeding eyelet machine. In construction it is not unlike the magnetic tacking machine, inasmuch as the eyelets (a gross or more) are put into a hopper seen at the top of the machine, the eyelets being carried down a sliding channel or 'roadway' on the right, to the setting instrument in front of the operator. This consists of a receiving nipple, upon which is delivered an eyelet. Another nipple seen above, and upon which is placed the 'closed upper,' previously punched with eyelet holes to receive the eyelets. The machine is actuated by a treadle, and the action is as follows: The lower nipple with the eyelet upon it is raised, forcing the eyelet through the hole in the closed upper above, and there clenching it. During this operation a cranked motion, attached to the side of the machine, withdraws the slide or roadway until the eyelet is clenched, when it returns to its former position and delivers another eyelet on the receiving nipple. The slide, or 'roadway,' through which the eyelets are delivered to the receiving nipple, is so arranged, by screws fixed in slotted holes, that it can be adjusted to any size of eyelet required.

In connection with this eyelet machine is used a self-feeding punch, which punches the necessary holes of the size desired to receive the eyelets.

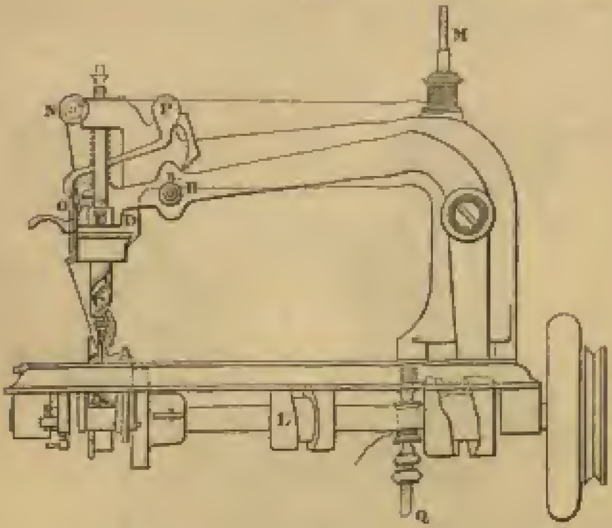
Sewing the Button Holes.—In those description of boots and shoes in which buttons are used as a means of fastening the boot or shoe to the foot, it is desirable to strengthen the leather, or other material in which the holes are made to receive the buttons; this is done by sewing around the edge of of the hole.

Some sewing machines have special arrangements adapted to produce this sewing. The machine selected for illustration is that of the American Button Hole and Sewing Machine Company, combining several other useful applications, such as hemming, braiding, cording, quilting, &c. *Fig.* 2257 represents the upper part of the machine for sewing.

Two threads are used: one supplied from the spool pin *m*, on the top of which is a

light weight. The second or under thread is supplied from a spool, which, with its tension, is arranged upon a spool post attached to the under part of the bed of the machine Q (*fig.* 2257). The first thread passes through a hole in the tension wheel N, through the thread guide O (in the direction from you), through the hole in the end

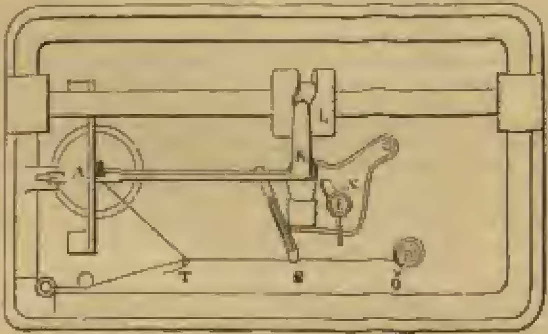
2257



of the take up P, and again through the guide O (in the direction towards you), and then through the eye of the needle.

The second thread is supplied through an under needle, which is moved by the central cam L (*fig.* 2257). In making the stitch, this needle rises above the bed of the machine, and delivers a loop over the edge of the material on which the hole is being

2258



worked. A third reel supplies the bar thread, which is threaded through the needle plate, and passes around the edge of the button hole. Over this thread the 'pearl' of the stitch is thrown, giving a flush finish to the button hole.

In sewing, the material is placed beneath the needle, always entering the needle as far as possible in the material before lowering the presser foot; the machine is now put in motion; by turning the wheel from you the material is gently guided; but not pulled, as it would likely involve the breaking of the needle, and produce irregular sewing.

The machine is self-feeding, and it is only necessary the operator should guide the

material to be sewn. Before removing the work, sufficient slack thread is drawn from the upper spool to prevent bending or springing the needle.

To change the machine from plain sewing to a button hole machine, a re-arrangement of the sewing apparatus takes place.

Fig. 2258 represents the under part of the machine, arranged for making button holes, and for over seaming. The shuttle is removed by pressing back the latch, A, and the button plate placed in position above, the needle threaded through the upper eye, and the heavy weight on the upper spool M (*fig.* 2257) . The presser foot used for button hole work is one having the greatest curve. Without entering into minute details, the following are the general arrangements :—

The spool is placed on pin Q, so that the small end will enter the spool: upon this a spring is placed and screwed by a nut, to regulate the tension, and a second nut securing the first. The machine is now adjusted; the screw X is loosened, and the roller on the looper arm K is brought opposite to the unit O on looped cam L, the looper arm K is pushed up as far as possible, and the screw X tightened; all is now ready for working. For button hole work a slower speed is desirable than for ordinary sewing; the belt is therefore placed on the outer groove of the driving wheel (*fig.* 2250).

2259

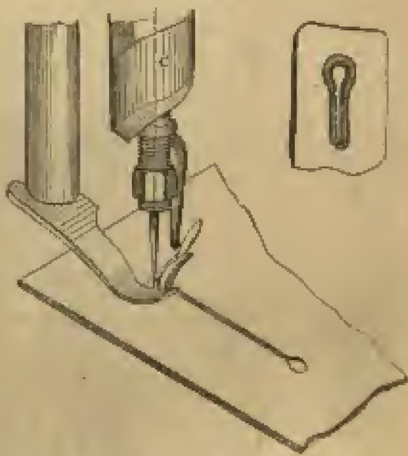


Fig. 2259 shows a section of the machine as arranged when commencing to make a button hole, and side by side a button hole complete. The hole is here seen as cut with the cutter; it is next placed around the guide on the throat plate, the right side of the material being next to the plate; the needle is now lowered until the point enters the material, when the presser foot is lowered, and the sewing proceeds. In working the round of the hole, the material is turned steadily, and with slightly increased motion given by the hand to prevent the stitches crowding. The sewing should always be commenced at the end of the hole opposite the round. The tension on the under spool for button holing and over seaming may be as light as possible when cotton thread is used; when silk, a little stronger, and varied according to the thickness of the material; while in over seaming the upper tension necessary is less than that required in button hole sewing.

The button hole being finished, the presser foot is raised, while the needle is in the material; the needle is then raised to its highest point, a small portion of the thread being drawn from the upper spool; the material is then drawn towards the operator, care being taken that it should not catch the point of the needle.

Eyelet hole work is also sewn by the above described arrangement; it is necessary, however, to lengthen the stitch for this kind of sewing, and allow the feed to turn the material; eyelet holes for sewing should be pierced or punched, and not cut.

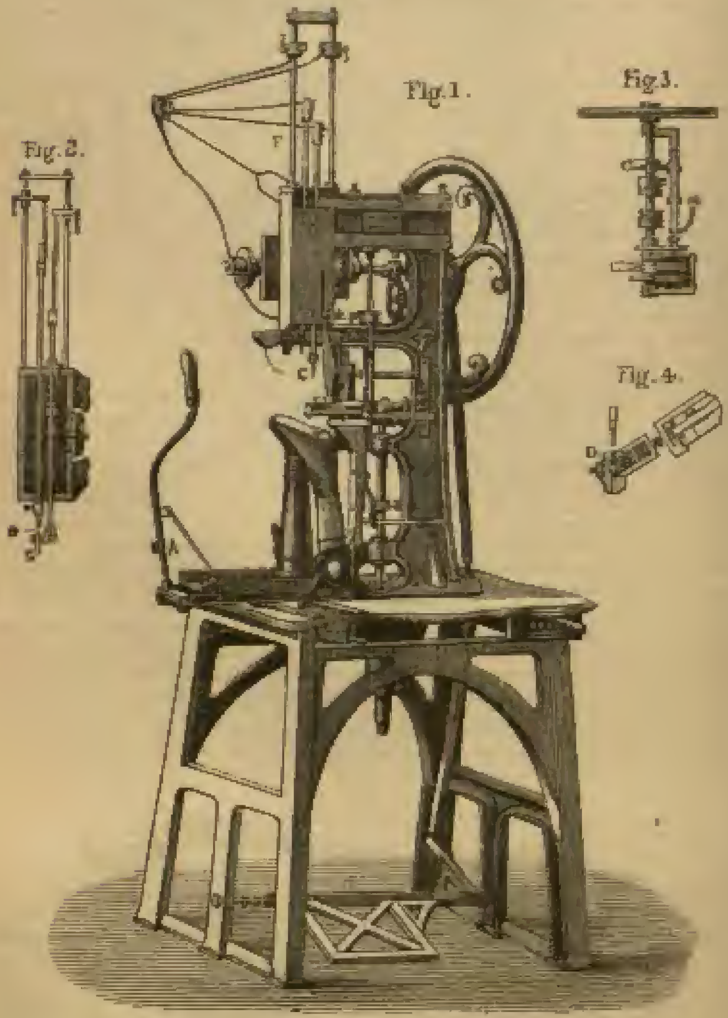
2260

Button Fastening.—The ordinary mode of attaching or securing buttons to boots or shoes is by sewing with a strong waxed thread the shank of the button to the leather

or other material. Another method is now in very general use—the arrangements will be see in *fig.* 2260 and is known as HEATON'S Patent Button Fastener. The instrument is a hand tool, and about the same size and weight as shoe makers' pincers. A small metal staple, seen to the left, and having three legs, is the fastener by which the button is secured to the boot.

The shank of the button receives the longest leg of the staple, which, being duly inserted, is put into the slot in the upper jaw of the pliers, a small spring latch keeping both staple and button in position. The work upon which the button is to be set is placed between the jaws of the pliers, and resting on the lower one; the handles are then pressed firmly together; by this action the legs of the staple are forced through the material, and, coming in contact with the lower jaw, are clenched on the under side. The grooves in the lower jaw give the legs of the staple a uniform direction when clenched, as seen in the sketch to the right of the above figure.

2261



Hitherto attention had been directed in the manufacture of shoes to the sewing or stitching of the soles to the uppers. Other methods are employed, namely, riveting,

and pegging by screws and pegs. One or two illustrations will show how this system of boot soleing is generally carried out.

Fig. 2261 is a boot soleing machine invented by Mr. HENRY KUHLMANN, of Gluck, stadt, in Germany, and in use to a limited extent in this country. The machine will put the outer soles on 'pegged' boots at the rate of one sole per minute when worked by one man, and probably at a much more rapid rate if it were driven by power. In doing this work it makes the holes, makes the pegs, and drives the pegs into the holes, either in one row or in two 'zigzagged,' as may be required. The general characteristics of the machine will be understood from the illustrations above.

The machine stands about seven feet high to the top, and occupies about one square yard of floor area.

The boot to be soled is fitted on a last, and has the outer sole 'sprigged' on to the inner sole with a few small sprigs or tacks. The position of the boot with the last within it on the machine is shown in the engraving. By the aid of a ratchet wheel at the end, the slide carrying the last can be made to advance the distance between each peg at each stroke of the machine, while, by the aid of the two handles shown, the boot may be moved by the operator, so that the curve of the sole will be brought under the awl and the hammer. *Fig.* 1 is a general view in perspective; *fig.* 2 is a front view, showing the awl and hammer in detail; *fig.* 3 is a plan of the driving shaft and cam; while *fig.* 4 shows the arrangement for cutting off the pegs, and the hammer above in position ready to drive one home. The action of the machine is as follows: The shoe or boot, sole upwards, and containing the last, is fastened on a slide, which can be moved horizontally to and fro. It is then brought under the point of an awl, B, which, after making a hole in the sole, is immediately raised up.

A gutter with a vertical channel (*fig.* 4) contains the peg, and leads it just over the hole made by the awl, and a hammer, C, coming from above, passes the channel and drives the peg into the sole, whereupon the hammer is again raised up. The boot or shoe is then advanced the distance of a peg, the channel again returns, the awl makes another hole, and gives way to the gutter with a new peg, which is driven in as before. A bar of flat iron, with a groove made in the whole length of it, of the same breadth as the length of the pegs to be cut, traverses from right to left in a dovetailing guide moving up and down in a dovetail. The horizontal motion of the bar is produced by a slide, when it pulls a pin, catching in the slit of it, to and fro.

The vertical motion is produced when the bar is moved up and down with the dovetailing guide. On the under side of the bar is a box of plate iron, in which are placed thin strips of hard wood of the same thickness as the pegs required to be made, and as broad as the latter are to be long. In these strips of wood the grain runs transversely, so that they can be easily cut into the size of the required pegs. Each strip is planed or sharpened at the edge, so that the pegs have a flat-edged point. The end of one of these strips is shown in *fig.* 4 at D.

The strips of wood are forced into a curved position by a screw working into a groove, and pressed against the groove in the bar by a spring and punch. They are then conveyed one by one between two wheels, one strip taking the place of another directly that other has been passed through the groove by the wheels. The curved position of the strips and their elasticity make them enter the wheels one after another. The larger of the two wheels is turned by a lever, ratchet wheel, and spring, so that it passes the strip to the left until it comes in contact with the holder. The whole transporting mechanism is mounted on the bar and follows its motion. At each motion to the left the lever touches a pin and bends a spring. Near the end of the bar is a knife, E (*fig.* 4), moved by a lever not shown. This knife makes stroke for stroke with the awl and hammer, cutting a peg or splinter off the wooden strip or ribbon at each stroke. As soon as the peg is cut from the strip it is moved forward to fill the hole made by the awl, and the motion of the lever being repeated at each motion of the bar to the right hand, the spring is always bent and ready to push the strip of wood forward. The peg being now in the channel before mentioned, is pushed by the hammer pin, C, through the channel, and driven into the hole made by the awl.

The guiding rod of the awl supports a lever, and has on its upper end a button seizing on the lower end of the spring, whilst the upper end bears against a catch, which, if screwed down, increases the power of the spring, F.

The motion of the hammer is effected in the same way as that of the awl, viz., by cam and spring, guiding and lever rods, and a catch to bend the spring.

Nothing can be more beautiful than the action of this machine. The awl first makes a hole, and then retires out of the way. The bar with the peg, D, then comes forward and holds the peg exactly over the hole. The hammer pin, C, then descends and drives the peg home, returning, its place is taken by the awl, which punches a hole; and so the work proceeds.

The wood employed for the pegs is of so hard and tough a nature that it shows no tendency to soften or even to wear down until the surrounding leather itself is worn away. This pegging machine, as previously stated, is but little used in England. It is, however, more extensively employed on the Continent, and in Prussia appears to be used in the manufacture of boots for the army.

Other machines, of which there are a few varieties, might be referred to. However, the general principles vary but little, and the KUHLMANN machine fairly illustrates the system of manufacture by wooden pegs.

In the manufacture of boots for the seafaring population pegging is more frequently employed than sewing, and the work endures so long as the boots are kept well saturated.

The importance and extent of the boot and shoe trade in Great Britain will appear in the following figures, deduced from the Census returns and furnished by Dr. W. FARR, F.R.S., of the General Register Office, Somerset House, from which it will be seen that the total number of persons employed, as enumerated in the Census of the year 1861, was 279,460 of all ages, compared with 248,717 in the year 1871, when the last census was taken.

Of the persons employed in the year 1861 there were 238,009 males and 41,451 females, the numbers in 1871 being 221,626 males and 27,121 females. In addition to the above numbers it appears that a large proportion of shoemakers' wives frequently assisted their husbands in their business, numbering 90,970 in the year 1861, against 103,340 in the year 1871. These last figures are altogether supplementary, but serve to show the extent of labour engaged in the manufacture.

In the annexed statement appears the total number of persons engaged in the boot and shoe trade in the following towns in the year 1861, including all ages, and distinguishing males from females:—

Towns	Males		Females		Total	
	Under 20 years	20 years and upwards	Under 20 years	20 years and upwards	Under 20 years	20 years and upwards
Stafford . .	452	1,264	348	387	800	1,651
Leicester . .	534	1,362	352	492	86	1,854
Northampton .	1,089	3,426	1,037	707	2,126	4,133
Wellingborough .	not retn'd	1,985	not retn'd	379	not retn'd	2,364
Norwich . .	672	2,480	471	1,620	1,143	4,100
Leeds . . .	426	2,262	147	428	573	2,690
London . . .	4,590	28,891	1,814	7,405	6,404	36,296

In the returns for the same towns for the year 1871 are included males and females of twenty years of age and upwards only, as appearing in the following, the figures for Wellingborough and London alone including all ages.

Towns	Males	Females	Shoemakers' wives	Total
Stafford	1,007	278	907	1,685
Leicester	3,714	1,389	1,977	5,103
Northampton	4,641	852	2,860	6,493
Wellingborough . . .	2,210	568	—	2,777
Norwich	2,740	817	1,479	3,557
Leeds	2,720	388	1,555	3,108
London	30,914	4,699	—	35,613

The figures in the column 'shoemakers' wives' represent the number who frequently took part in their husbands' business in excess of the above total.

In England and Wales in the year 1861 there were 250,581 boot and shoe makers. Of this number there were 35,687 males, and 10,311 females, under twenty years of age, and 175,536 males and 29,047 females, of twenty years of age and upwards. Against a total of 223,365 in the year 1871, of which number 26,107 were males and 8,439 females, under the age of twenty years, and 171,358 males and 17,461 females, of twenty years of age and upwards.

The exhibition of leather work, and of the machinery connected with boot and shoe manufacture, held in Northampton in the year 1873, brought together a most interesting collection, not only of the rough, curried, and fancy leather, but highly-

finished examples of the shoemakers' skill in sewing, including boots, shoes, and closed uppers, together with sewing and shoe machinery, and the various tools employed. Since that date considerable advance has been made in the adaptation and application of machinery to all branches of the shoe trade; indeed, there is scarcely another industry, of the many abounding in the kingdom, in which machinery has been applied with more success.

Shoe manufacture is widely diffused throughout the land; in many towns, however, it has attained great dimensions, and has become the principal trade therein. In the following towns, which may be regarded as the more important centres of the trade, the class and character of the work there manufactured is of the following description. For example, Stafford, and Nantwich, in Cheshire, has the reputation of making ladies' best work; Leicester, ladies' medium and various qualities; Northampton and surrounding towns, men's best work; Wellingborough, to a large extent boot and shoe uppers and leggings; Norwich, ladies' and children's work, the latter principally; Leeds, heavy, substantial work, and of late, army boots are taking the place of much of the ordinary work. Again at Rushden, Higham Ferrers, Raunds, near Thrapstone, and Irthlingborough, army boots are especially manufactured; Kettering, also, in Northamptonshire, is the seat of a large trade of men's boots of medium quality; Bristol, of recent years, has attained much importance as a seat of industry for the manufacture of men's, women's, and children's boots and shoes of medium quality.

Scotland, though richly endowed by nature in her mineral resources of coal and iron, has not lost sight of those other industries which contribute to progress. Glasgow, it may be stated, is the centre of a very important industry of men's and women's work of medium quality; Maybole, in Ayrshire, of men's heavy quality, and the same may be said of Linlithgow, in addition to army boots.

In London all varieties and qualities of boots and shoes are manufactured, including machine and hand sewn. In all the best varieties of work, namely, boots made to order, and known as the bespoke trade, the work is sewn by hand, and is of superior quality, from the excellence of the materials and the high class of labour employed. Establishments engaged in the production of this class of work abound in the west end of London, and the display of highly finished and artistic skill there exhibited shows the extent of the industry. London also abounds in numerous well arranged and admirably constructed works in which machinery is employed, with all the recent improvements, economising labour and securing increased production. In London and its surrounding districts it may be mentioned that the boot and shoe trade comprises upwards of 3,000 master boot and shoemakers. In concluding it only remains to append the official returns gathered from the annual statements published for trade and navigation, showing, since the year 1862, the exports and value of boots and shoes of all kinds, followed by the imports and value in each year since 1871, and succeeded by the details of the exports in 1875, showing the countries receiving the same, together with the details of the quantities imported into the United Kingdom and value in each of the years 1874 and 1875.

EXPORTS.

Boots and shoes of all kinds manufactured in the United Kingdom and exported therefrom in each year since 1862:—

Years	Quantities	Value
	Dozen pairs	£
1862	447,979	1,637,550
1863	370,774	1,405,810
1864	404,135	1,484,421
1865	430,283	1,462,105
1866	205,801	988,888
1867	274,030	952,804
1868	439,265	1,397,600
1869	436,329	1,326,702
1870	372,590	1,145,423
1871	506,928	1,615,771
1872	579,130	1,093,348
1873	527,604	1,707,566
1874	410,114	1,374,802
1875	462,840	1,517,267
1876	441,032	1,403,400

IMPORTS.

Boots and shoes of all kinds—the manufacture of foreign countries imported into the United Kingdom in each year since 1871:—

Years	Quantities	Value
	Dozen pairs	£
1871	44,229	138,304
1872	46,189	151,218
1873	40,304	146,731
1874	44,742	153,870
1875	84,733	240,000
1876	109,906	328,540

The *Imports* in the years 1874 and 1875 were received from the following countries:—

Countries	Quantities		Value	
	1874	1875	1874	1875
	Dozen pairs	Dozen pairs	£	£
Germany	6,222	9,940	25,891	34,471
Holland	3,922	3,320	17,575	14,181
France	29,940	67,274	96,414	180,484
Other countries	4,658	4,199	13,990	10,864
Totals	44,742	84,733	153,870	240,000

The *Exports* in the year 1875 were received by the following countries:—

Countries to which exported	Quantities	Value
	Dozen pairs	£
Egypt	4,670	13,244
Foreign West Indies	6,092	15,300
Central America	3,804	15,911
United States and Colombia	2,843	11,030
Peru	8,821	28,367
Chili	7,606	20,903
Brazil	37,720	141,791
Uruguay	6,210	11,171
Argentine Republic	34,014	101,629
Channel Islands	5,214	22,918
British Possessions in South Africa	94,153	314,663
British India: Bombay and Scinde	5,823	21,500
" Bengal and Burmah	2,558	11,297
Australia	186,688	603,251
British North America	7,124	26,373
British West India Islands and British Guiana	28,753	88,789
Other countries	22,747	69,881
Total exports in 1875	492,840	1,517,267

R. M.

BOOT AND SHOE CLEANING MACHINE. In connection with the article on the machinery used for boot and shoe making, it appears desirable to show how much ingenuity has been employed in cleaning the boot.

Two machines have been patented: one of these is the invention of Mr. SOUTHALL, of Leeds, who has designed a machine about the size of a small lathe or an ordinary sewing machine, and has contrived to impart to the brush the backward and forward movement which seems to be absolutely necessary to produce a polish on leather. A horizontal sliding shaft runs in bearings on the frame of the machine, a worm wheel

in one of the bearings acting as 'feed' for revolving the boot, which is held firmly on an expanding last. A rocking bar carries an arm to which the brush is attached, and is so fitted that the brush lever can rise or fall according to the inequalities of the surface of the boot. The driving shaft carries a worm for turning the feed, a fly wheel, a crank, and cams for giving the brush the backward and forward motion. The boot being secured on the last, and the brush adjusted to the proper distance, an ordinary crank handle is turned, and the polishing proceeds to a satisfactory termination. This machine only polishes the boot. What is wanted is a machine into which a dirty and probably muddy boot can be placed and cleaned and polished merely by turning a handle or by setting the machine in motion. Such a machine is promised by the specification of a patent obtained by Mr. W. H. Kent, of Blackfriars Road, for an invention which relates to improvements in machinery or apparatus for cleaning and polishing boots and shoes, whereby the dirt is cleaned off, the blacking put on, and the boots or shoes polished at one operation. For this purpose a pair of brushes have a straight reciprocal motion imparted to them; also a side action, allowing the brushes to take any angle to suit the shape of the boot or shoe to be cleaned. There is also an arrangement for contracting or expanding the distance between the pairs of brushes, and a revolving platform on which the boot or shoe is fastened, together with an arrangement for conveying the necessary quantity of blacking to the boot or shoe. A suitable frame of wood or metal is arranged with bearings to carry a shaft, having two or more cranks with rods attached, extending to blocks having the brushes hinged to them, with springs on the back of the brushes, arranged to keep a continuous pressure in whatever position the brushes are in. The slides carrying the blocks in which the brushes are attached work on rods on which they are caused to slide by means of a cam arranged at the lower part of the machine, levers being attached which expand or contract the space between the brushes. The boot or shoe is put upon a suitable last, which rests upon a platform running upon centres, the lower centre under the platform, the upper centre on the top of the last being kept in its place by suitable springs or levers, the platform and last revolving on their centres driven by cog wheels connected to main shaft. For conveying the blacking to the boot or shoe, a suitably shaped bottle of blacking is fixed to the bottom of the machine, in the centre between and just below the brushes. Inserted in the bottle is a round piece of wood of suitable diameter, and long enough to reach from bottom of bottle to the top of the case in which the machine is enclosed, and working through suitable bearings, with a knob attached on top. The lower part of the piece of wood that goes into the blacking has a coarse screw thread cut in it to hold the blacking when withdrawn from the bottle. When the blacking is to be put on the boot the knob is pulled up, the brushes then come in contact with the end of the piece of wood, and a few turns of the handle of the machine thoroughly blackens the boot, the knob falling to its place on withdrawing the hand. A few more turns of the machine and the boot is polished. The boot or shoe to be cleaned, and all the machinery being perfectly enclosed, there is no escape of dirt, the three operations—namely, brushing off the dirt, putting on the blacking, and polishing—being all completed in a few revolutions of the machine.

BOILERS. On the principle affecting the prevention of smoke in the firing of boilers. See Smoke, *Prevention of*.

BORACITE. (Vol. i. p. 431.) See also Boracic Acid. Has lately been obtained from the residues of chloride of potassium in crystals of three varieties. They contain boric acid and magnesia, with small quantities of ferrous oxide and chlorine.

BORAX, *its Action on Fermentation.* Pasteur showed that borax coagulates yeast, prevents the inversion of sugar, stops the action of diastase, and paralyses synaptase.

M. J. B. Schnetzler made a full examination of the action of the borate of soda on easily fermentable substances.

In a concentrated solution of borax, the protoplasmic movements in the cells of *Elodea Canadensis* were gradually arrested, and the cell contents agglomerated in masses containing granules of chlorophyle.

The protoplasm of *Vaucheria* was similarly coagulated.

Grapes attacked by *Oidium Tuckeri*, when immersed in water, showed a molecular movement, as well as protoplasmic currents. When immersed in a solution of borax the fungus was killed, but the molecular movements continued. Grapes placed in a concentrated solution of borax in closed vessels were not fermented in two years and four months.

Infusoria, Rotifera, and Entomostraca had their movement arrested in solutions of borax, and the sarcode of the infusoria was contracted and coagulated.

Currants in a borax solution were not fermented, but, with access of air, mucor was developed without fermentation.

A patient, when there was a considerable formation of sugar in the urine, took 30 grains of borax each day for a fortnight. During this period the sugar could not be detected by the copper test, but the borate of soda disturbed the stomach to such an extent that he was obliged to abandon its use.

The antiseptic properties of borax are claiming attention.

Fresh milk mixed with a little borax remained fresh for three months.

Mutton and beef were kept for several months by being powdered with borax.

J. B. Schnetzler, *Comptes Rendus*, lxxx.

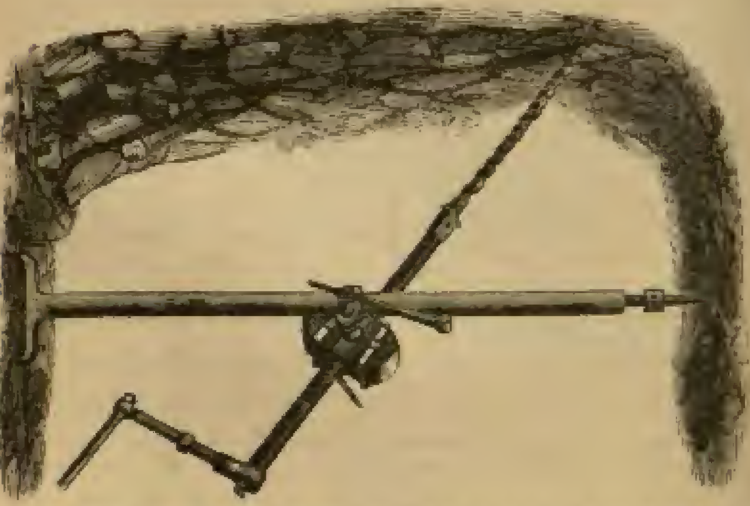
M. Bedoin states that fresh meat, corked up in a bottle filled with a saturated solution of borax, was found fresh 54 days after. There were no traces of any living organisms. Meat similarly treated with river water was found to give off the ammoniacal odour of decomposing animal matter, and the liquid was full of *bacteria*.

Comptes Rendus, lxxxii.

BORING. (Vol. i. p. 434.) Since the publication of the article on boring in Volume i., a few machines have been introduced which have, each of them, some points to recommend them. Amongst others, Macdermott's Patent Rock and Coal Perforators must be named. The accompanying wood engraving will sufficiently show the general character of this rock perforator (*fig.* 2262).

This type of Patent Perforator is suitable for almost all kinds of drilling in rocks and shales. It can be fixed and unfixed almost instantaneously, and is at once ready for work. The automatic feed renders it adaptable to almost every variety of material; whilst for drift work, for rippling down roofs, or blowing up floors, its capacity of ready adjustment to any angle or position of hole, and the ease with which it can be carried from place to place, have made it, when the men have once got accustomed to its use, an indispensable adjunct to colliery work. When the hole has been bored, the drill, with the stuff in it, can be instantaneously withdrawn, without turning

2262



in the hole. This is a most important advantage, as it prevents the possibility of clogging.

This, which is called the 'Grip' Standard, can be fixed, without any frame or other adjunct, to any face of rock, horizontal or otherwise. Two iron legs, pivoted so as to form a St. Andrew's Cross, are fitted at their upper ends with a screw, capable of forcing them asunder. The lower ends, or feet, being fitted into a couple of holes hewn in the rock which it is desired to pierce, are firmly fixed there by the action of the screw. A third limb steadies the frame, and takes the back-thrust of the boring tool; while upon the horizontal tube in which the connecting screw works is clamped the perforating mechanism. (*Fig.* 2263.)

The mode of operating is as follows:—Cut two nicks roughly in the material to be bored, and insert therein the points of the St. Andrew's Cross, and, if necessary, make a third nick for the back-stay bar. Then turn the nut on the screw until a sufficient pressure is brought to bear on the sides of the nicks to render the standard rigid and

fixed in position. Adjust the screw and auger to the required direction and position, and clamp them.

2263

This type of perforator is especially adapted for open quarry work, as the standard can be fixed independently on any face, whether it be horizontal, vertical, or at an angle; and it requires no frame or other adjunct whatsoever.

The illustration, *fig.* 2264, represents the Rock Borer of Messrs. ULLATHORNE and Co., called by them the 'Champion,' mounted on an adjustable tripod stand, suitable for sinking shafts, or for quarrying purposes.

2264

The 'Champion' Rock Borer is said to penetrate the hardest rock. It works with steadiness, and can be driven at great speed if required with perfect safety. The rate of progress varies from 3 inches to 15 inches per minute, according to the diameter of the hole, the nature of the rock, the size of the machine, and the pressure of the motive fluid. It will bore perfectly round holes in any direction, and the drill clears itself as it progresses. The piston rod carrying the steel drill is caused to partially rotate on each backward stroke, and is allowed to travel without turning on the forward stroke, by an arrangement which is simple, and which causes regularity of rotation.

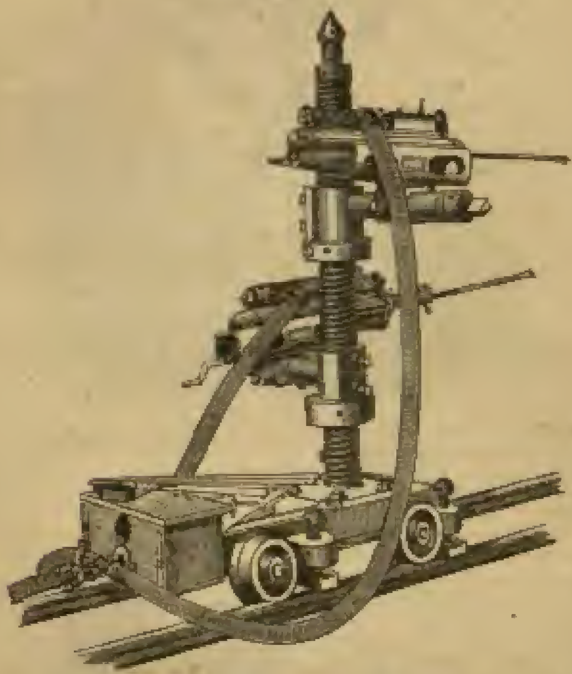
This rock borer is wound forward as the drill penetrates the rock, either automatically or by hand at option.

The same machine may be used for sinking, drifting, or open work, and, if required, it is specially constructed to

bore holes of upwards of 3 ft. deep without change of drill. It may also be used for submarine work.

The illustration (*fig.* 2205) represents two of these rock borers mounted on a complete and adjustable carriage, specially designed for driving levels. It will be noticed that by means of the movable arms on the carriage, and the universal clamps on the arms, the rock borers may be directed and fixed to bore at any point, and in any direction, to suit the wants of the miner, so that much time may be saved by boring a number of holes, without moving the carriage, after it is once secured in position. To the back of the carriage is fixed a convenient tool-box, and a pressure gauge is provided, so that the precise pressure of air driving the rock borers may always be known. A small jet of water at a high pressure is directed into the holes as they are being bored.

2205



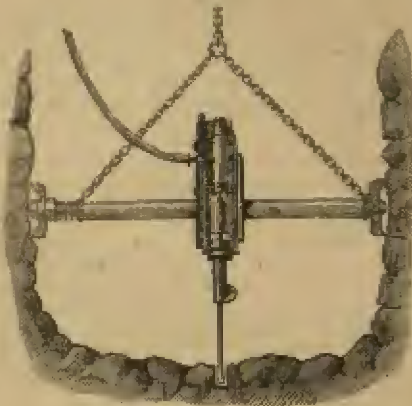
The rock borers possess the great advantage of being able to be worked with a very low pressure of air, and a pressure of only 35 lb. to the square inch will enable them to bore a $1\frac{1}{4}$-inch hole with great rapidity. They weigh only $1\frac{1}{4}$ cwt. each, and are short and handy. Each rock borer is provided with a perfect self-acting feed (readily put in or out of gear), which causes it to be steadily wound forward in its jacket accurately in proportion as the steel drill penetrates the rock, without dependence on the skill of the attendant. By means of this automatic feed much greater speed is attained, and it allows the attendant to give a general supervision to the machines and carriage, and to see that everything is working properly, which he could not do satisfactorily if he had to be winding forward by hand. Anyone who has practically worked a rock borer with a perfect automatic feed will appreciate its great advantage. The rotation of the steel drill also is automatic, so that perfectly round holes are ensured, and there is no undue wear on the steel. Considering the completeness in all the details of the rock borers, they are wonderfully compact and simple, and being specially constructed with a view to durability, there is little danger of breakage or derangement, while the wear is reduced to a minimum.

The rock borers are driven by air, compressed by an air compressor, conveyed into the workings in wrought-iron pipes. The air compressor may be compactly mounted on one bed plate, with either a steam-engine or a water-pressure engine, or it may be driven by an independent engine, water-wheel, or turbine. Where a considerable head

of water is obtainable, a combined water-pressure engine and air-compressor is a most convenient and economical way of securing the greatest advantage from the water. The air compressors supplied with the 'Champion' Rock-Borers are specially designed so as to be as simple as possible, and are without any complicated or delicate adjustments; the air-pumps are surrounded by water-jackets, and a small spray of water is taken in at each stroke, so that the compressed air may be kept cool.

This borer may be mounted on an improved stretcher bar, as shown in *fig.* 2266. This bar (which may be constructed of any required size) has an extension screw to vary its length, and to secure it firmly in position. The machine can be moved and clamped to any part of the bar. The stretcher bar is the simplest, firmest, and best support for sinking small shafts, and being portable, it is admirably adapted for driving levels, headings, &c. It may be used fixed either vertically between the roof and floor, or horizontally between the sides of the level. Modifications of the stretcher bar may be made according to requirement.

2266



The following description of the deep boring apparatus in the Haselgebirg is given by A. AIGNER (*Oest. Zeitschrift für Berg und Hüttenwesen*, No. 16, 1874):—

Exploration by means of shafts has the advantage of affording visible inspection of the strata. By first making trials with hand-borers the danger of meeting with water may be avoided, although this method is expensive and demands time. The proper speed can only be attained with a free-falling boring instrument; but the nature of the Haselgebirg, and the entire non-appearance of water, led to a modification which may be of service in carrying out similar undertakings. The boring rod is fixed to the lever by the usual adjusting screw. The boring bar has a diameter of $\frac{1}{4}$ of a foot, and is in convenient lengths screwed together. The lower portion consists of a KIND's boring instrument, as improved by WLACH, and of a cutter weighing 60 lb., with side blades cutting to 10 inches diameter, the weight of the lower rod being $3\frac{1}{2}$ cwt. (4 centner). The results proved it to be well adapted for boring in the Haselgebirg. The side of the bore hole is not injured by blows from the rod, nor does it require to be supported by tubes while it is dry and truly cylindrical, the diameter—10 inches—not being observably diminished.

The results obtained with the apparatus for cleaning out the bore hole were not so satisfactory. Revolving scoops were employed for the purpose. At a length of 75 feet (12 klafter) the torsion of the scoop rod and the excessive friction rendered further proceedings impossible, as the boring rod made nearly a whole revolution at the turning point before the scoop began to work, and the only remedy thought of was the introduction of water or brine. But this did not answer for various reasons, chiefly because it interfered with the proper examination of the various strata. To continue the dry boring an apparatus was specially designed by FR. RITTERSBACHER, which proved successful, for not only was the bore hole easily kept clean, but the quantity of work done by the borer was increased. This cleaning-out apparatus is of two designs.

In one it consists of an exterior forked vertical frame, to the lower ends of which are attached two cylindrical metal tubes, open at the top and at the bottom, brazed together. At the upper end of the frame there is a round hole, in which the upper and circular portion of a toothed rack works up and down. Somewhat lower than the middle of the frame a horizontal cross-bar is bolted to it, through which work two spindles, at the upper end of each of which is fitted a bevel wheel, and at their lower ends each has a steel lifting screw, provided underneath with a cutting edge. These screws revolve at the level of the bottom of the tubes. Just above the cross-bar revolves a horizontal spindle, to each end of which is fixed a spur pinion gearing into the bevel wheel just mentioned. In the middle of the spindle is a spur wheel, worked by a toothed rack—a catch and pawl arrangement only permitting it to revolve in

one direction. The upper circular portion of the toothed rack and forked frame are weighted to 15 lb., to give the necessary downward pressure to the scooping apparatus. At the upper circular end of the toothed rack, working up and down in the frame as before mentioned, is attached a ring for the rope used for raising and lowering the scoop apparatus.

The second design consists of a similar exterior frame, to the lower ends of which is attached a sheet metal casing, open at the top and bottom, while at the top of the frame (as in the first method) a hole permits of the up-and-down movement of a rod. An interior frame, of the same shape as the exterior frame, is attached to the rod, fitting closely to, and working within, the exterior frame. To the upper end of the rod, above the exterior frame, is fixed, as in the first case, an iron ring, to which is fastened the rope for raising and lowering the apparatus. At the lower part of the sheet metal case are two movable doors or sliding pieces, pressed down by a lead weight fixed to the interior frame. Either of these clearing-out machines is raised and lowered by a small windlass, having mechanism for changing the position of the jib, and fitted with a break. The boring rod is furnished with an indicator, as the cleaning-out machine can only be let down on the two vacant or open sides of the boring apparatus.

The manipulation is as follows:—Whilst the men working the machinery are resting, the cleaning-out apparatus is got ready to extract the *débris*. This, in the case of the second design, is done by drawing the interior frame upwards by the ring, forcing at the same time the top of the exterior frame downwards, until the top of the former meets the under edge of the latter, in which position the sheet metal case is open underneath. The scoop apparatus is then lowered to within one foot of the bottom, and allowed to fall freely; upon which the *débris* enters the casing, the movable feathers close underneath, and the apparatus is raised and emptied.

The same process is gone through in using the first apparatus, only with the difference that instead of the movable feathers or slides, the rotating screw forces the *débris* upwards.

So far as experience goes, this scoop apparatus is available to a depth of 218 feet (35 klafter). The following table shows the difference of effect between the old plan for a depth of from 0 to 75 ft. (0 to 12 klafter), when its further employment becomes impossible, and the new system, which worked from 75 to 187 ft. (12 to 30 klafter), it being borne in mind that impediments increase with the depth:—

Depth in Vienna Klafter (6·22 ft. English)	8 hour spells	Men	Blows	Heights lifted in Zoll	Description of ground bored
		Number			
0 to 10 10 ,, 20 20 ,, 30	1,078 840 760	8 8 and 9 9 and 10	25,000 24,000 22,000	12 12 12	Salt, clay, and gypsum

It is possible that with increase of depth the bending of the boring rod may render it difficult to introduce the cleaning-out apparatus while the boring rod is down. The remedy would then be the introduction of light guides; but should this not suffice, the boring bar must be unscrewed and the boring apparatus lifted, when the scoop apparatus could be used for getting up dry borings from great depths. The first-mentioned apparatus is already in use where, in case of the boring machinery being under repair, the hole is clear from obstructions.

Another scoop apparatus consists of interior and exterior forked frames somewhat similar to the foregoing. To the two forked legs of the exterior frame, and at their lower ends, is fixed a sheet-metal tube open at the top and bottom. A vertical spindle is continued on the top of the interior frame, which works through a hole in the upper part or bow of the interior one. The fork legs of the interior frame are furnished with teeth gearing into small spur wheels on a horizontal spindle at about the middle of the apparatus, a crossbar underneath keeping in position a vertical shaft, having at its upper end a bevel wheel gearing into a smaller one on the horizontal spindle. The vertical shaft reaches from about the middle of the apparatus to the bottom of the tube, where it carries a screw of steel plate, which rotates, and so screws up the borings.

In this case the *modus operandi* is as follows:—The scoop is let down the bore hole until the screw bears on the bottom, when the rope is loosened and the interior frame sinks down by its own weight, until the ring attached to the upper part of its spindle

rests on the upper part or bow of the exterior frame. The downward movement causes the horizontal spindle to make a couple of revolutions to the left (without effect, owing to the catch and pawl mechanism), and when the scoop rope is lifted the revolutions take place to the right, the vertical shaft revolves twice, causing the screw and tube to enter the borings about 3 inches, and the apparatus is lifted out.

At Ischl by this means the salt formation has been examined to a depth of 510 ft. (82 klafter) from the surface. The scoop apparatus will recommend itself in all cases where, as in the Haselgebirg, the ground is light, dry, and solid.

At the Amber mine at Norty Len in Samland two shafts were sunk to the depth of about 127 feet, of which H. Klose gives the following description:—

'The boring head was a horizontal bar carrying four chisels for cutting into the bottom of the hole, and two at each end radially for describing the outer curve of the shafts. It weighed about 17 cwt. The boring rods of wrought iron were of two sizes; one being an inch square, used in boring percussively; and the other, 2 inches square, used when a twisting strain was applied.

'The sand pumps, or shells, for removing the *débris* produced in the boring, were of two sizes; the larger being 3·1 ft. and the smaller, 2·1 ft. in diameter, the length in each case being 6·4 ft. They were wrought-iron cylinders with slack valves at the bottom, but the suspension was so arranged that when brought full to the surface they could be emptied by being tipped like a bucket—without the necessity of being detached from the rods.

'The iron tubes lining the shafts are of best boiler plate 0·8-inch thick and 4·8 feet internal diameter—in lengths of 4 feet joined by internal rings of the same thickness and rivetted. The tube is further strengthened internally by small longitudinal strips of iron of the same thickness. The bottom length of tube is of double thickness, and terminates in a cutting shoe of triangular section. The total weights of the lining tubes are 44 tons per shaft, No. 1—and 45·6 tons per shaft, No. 2, or rather more than 1 ton per linear yard.

'The sinking of the tubes was effected by pressure applied by screws. A cast-iron ring grooved underneath to fit the tube, and having four perforated lugs through which the pressure screws passed, was placed on the top of the tube, and the pressure was applied to the nuts by men working spanners. The lower ends of the screws were attached to a fixed point or abutment formed by a timber platform loaded with cast iron: four screws were placed at equal distances around the circumference of the tube. The spanners were slung by tackles for convenience of manipulation, and from 4 to 5 men worked at each, so that from 16 to 20 men were employed in pressing down the cylinders. The amount of material displaced for each length of tube was about 53 cubic feet, which was removed in 4 or 5 fillings of the larger sized shell in about 8 working hours. The sinking of the tube occupied about 4 hours, so that one complete length of the shaft tube was sunk, and a fresh length slung and adjusted for rivetting in each shift of 12 hours. From the sandy nature of the ground, but little actual boring was required, the use of the chisels being confined to cutting through the beds of the shell.

'The work was done in day and night shifts of 12 hours, with an average of 27 men.

'No. 1 shaft was completed in 121 shifts, and No. 2 in 106 shifts, including both boring and rivetting. The latter operation occupied more than half the time.

'The total cost of the two shafts was as follows:—

	£
Wrought-iron lining tubes	4,093
Boring plank	1,239
Carriage	720
Labour for rivetting and sinking	715
	6,767

'The water level during the sinking was constant at 32·8 ft. below the surface, the shaft being about 46 ft. above the bottom of the valley.'—*Zeitschrift für das Berg-Hütten und Salinenwesen*, xxii., parts 3 and 4. Abstract in the *Proceedings of the Institution of Civil Engineers*.

On Machine Boring in Shaft-sinking.—The following results have been published as obtained by the use of Sachs' boring machine in a new sinking at Tremberg, near Steele, in Westphalia. The shaft, measuring 14·8 ft. by 10·4 ft., was sunk in slate and sandy shale to a depth of 241·2 ft. in 6 months, or an average of 40·2 ft. per month, using 6 machines. The borers, of best Styrian steel, required sharpening after boring from 31·38 ft. to 5 ft., and under the most favourable conditions a machine held out from 12 to 22 shifts, without requiring to be removed for repairs.

The proportion of machine to hand bore-holes was as 2·73 to 1. The former averaged 3·9 ft. in depth, and from 1·2 in. to 1·8 in. in diameter, while the latter were 2 ft. deep and 1 in. broad. Blasting was effected with dynamite and safety fuse. The total number of hands employed at the shaft bottom, including those employed in filling tubs with rock, was from 20 to 24. The cost, per foot, of this sinking was at first 6*l.* 5*s.* 9*d.*, but was subsequently reduced to 4*l.* 10*s.*, exclusive of the cost of drawing the rock to the surface.

With the same machine at the Carolus Magnus Colliery, near Berge Borbeck, the average result obtained in driving a level through similar rocks, 8·2 ft. high, and 7·2 feet broad, was 31·5 ft. per month over a period of 2 years.—*Oest. Zeitschrift für Berg und Hüttenwesen*, July 5, 1876, p. 286.

On the Use of Boring Machines at Schemnitz.—The deep adit level known as Joseph the Second's adit at Schemnitz, which was commenced in 1782, is intended to be of a total length of 17,327 yards, or about 1,420 yards longer than the St. Gothard Tunnel. Of this length, 15,320 yards have been driven by hand labour during the course of 92 years, leaving 2 sections unfinished, one of which is 1,604 yards, and the other 1,000 yards long. In the latter section the use of machinery was commenced experimentally in the year 1873, and was continued at intervals during the following year. In the first series of experiments 1 machine of Sachs' construction was used, the average depth of the bore holes being 1·3 foot, which were charged with dynamite, and fired by means of fuse. The average daily advance of the level, which was 8·5 ft. high and 6·9 ft. broad, was 2·1 ft. In the second series 2 machines were used, and the charges were fired by electricity; the result was a daily advance of 3·28 ft., the rock being, as in the first series, a moderately hard trachyte (rhyolite). In the third series 2 machines on an improved frame were used, the holes being 2·3 ft. deep; the advance was 0·8 inches per day in greenstone. In the fourth series, when the men were becoming better acquainted with the use of the machines, the average length driven per day was 4·8 ft. Great difficulty was at times experienced in the use of the electrical apparatus from missfires, especially when the air in the level was highly charged with moisture. It was found most convenient to have 2 machines, which were used alternately, and only taken into the mine when the holes were loaded and ready for firing. It was also considered desirable not to fire more than 12 holes at one time.

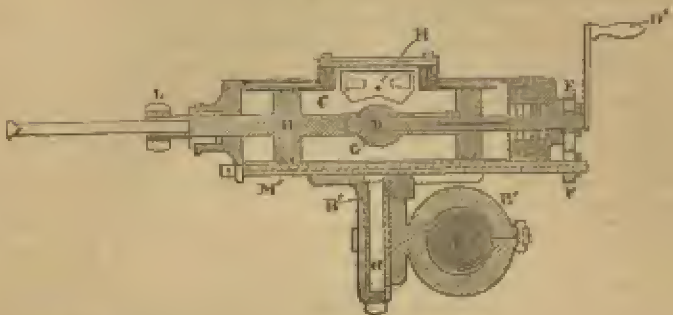
In order to obtain a basis for comparison with hand labour, a fifth series of experiments was made by 12 selected miners, working 4 at a time, 8-hour shifts, under continuous supervision; when it was found that 12 men in 4 days advanced 11·5 ft., equal to 2·9 ft. per day, thus producing somewhat less effect than a single machine.

Although the latter works at a disadvantage as compared with hand boring, on account of the time taken up in adjusting the stand and the accessory operation of laying railways and bringing up air and water pipes, and also because of the necessity of clearing away the whole of the rock blasted in one operation before beginning upon a new face, the author considers that there is an undoubted saving in time to be effected by the use of the machine. The most advantageous method of arranging the bore-holes is considered to be in four vertical lines about equal distances apart, but having the holes in the centre rows somewhat closer together than those at the side, there being 6 in each of the former series, and only 4 in the latter. By this arrangement, a uniform depth of 2·3 ft. being adopted as a standard, the stand only requires to be fixed twice for each set of 20 holes. The 2 central rows are loaded to a third of their depth with dynamite and fired first, making a deep notch in the face. This increases the effect of the side holes, which are fired subsequently with a somewhat smaller charge. Deep holes are not considered economical, as their effect is not found to be in proportion to the increased consumption of dynamite, besides being more uncertain than shallower ones. In conclusion, the author compares the results obtained with those of the St. Gothard Tunnel in 1873, when the drift at the Göschenen end was advanced, by 6 of François and Dubois' machines, 6·2 ft. per day, or 12·2 in. per machine; while at Schemnitz at the end of 1874 2 of Sachs' machines drove at the rate of 3·4 ft. per day, or 20·4 in. per machine. In the former cases 62·6 per cent. of the total depth of holes bored proved effective, while in the latter the proportion was 75·2 per cent., a result which the author attributes to the electric ignition, and the method of firing adopted. The cross sections of the two levels are at St. Gothard 6·55 square ft., and at Schemnitz 58 square ft.—L. Marker, *Oest. Zeitschrift für Berg und Hüttenwesen*, July 12, 1875, p. 291.

The Barrow Borer or Rock Drill.—A trial of this machine was first made about two years ago at Dolcoath Mine, in the county of Cornwall, which was not, however, so satisfactory as expected, several improvements having since been effected in it, among others a diminution in the size of the borers used. The present trial has been pronounced unprecedentedly successful by all those who have seen the machine at work.

which includes some of the leading mining authorities of the West of England; its light weight and consequent portability, the great facility with which it can be brought to bear on any point in the back, bottom, sides, or end of the level, the small space it occupies, and the extreme simplicity of the machine and its accessories, being considerations of the highest practical importance.

2267



C. Cylinder.
D. Piston.
D'. Spindle.
D''. Handle.
G. Tappets working valve.
E. Pinion on spindle.
F. Pinion on feeding screw.

H. Valve.
M. Feeding screw.
B. Column.
B'. Clamp.
L. Screw fastening borer.
a. Gudgeon.

The Barrow rock drill (*fig.* 2267) consists essentially of a horizontal cylinder about 2 ft. in length and 4 in. in diameter, in which works a cast-steel piston rod fitted with two pistons about 12 in. apart, midway between which is the tappet or boss. In a valve box on top of the cylinder is placed the oscillating slide valve, which is worked by the tappet coming in contact with the lower edges of the slide valve, which for this purpose are formed with two slopes at each end. The cutter has ports corresponding with openings in the slide valve face for admitting the compressed air, or steam from the inlet pipe, to the ports at each end of the cylinder, and for letting the spent or exhaust air or steam escape by the exhaust pipe.

This simple and compact arrangement constitutes the whole valve gear of the machine.

The borer is inserted into a hole formed in the front end of the piston rod, and fixed therein by means of a screw. Its rotation is effected by hand by means of the handle turning a spindle, which is so fitted, by means of the cutter made fast in the piston and fitting in a slit in the spindle, that the latter can slide in the piston, but when turned by the handle causes the piston to turn with it. The spindle has a pinion gearing on the adjusting and feeding screws, so that when the piston is turned by means of the handle, the cylinder is simultaneously pushed along the bed plate. This pinion can be easily disconnected by loosening the nuts, and thus the piston and the adjusting screw can be turned independently of one another when required.

The borers used are respectively 1¾ in., 1½ in., and 1 in. in diameter, the length of the stroke 4 in., and the maximum number of blows about 300 per minute.

The air is brought down the shaft in cast-iron pipes at a pressure of from 50 to 55 lb. to the square inch, and admitted through a flexible tube into the inlet on the left hand side of the cylinder. The air is compressed at surface by a 14 in. compressor, worked by a 12 in. horizontal engine, capable, however, of working two more machines if necessary. The cast-iron pipes are 3 in. diameter in the shaft, and 1½ in. in the level. The total weight of the machine, including bed plate and gudgeon, is about 115 lb.

The method of fixing the machine for work is as follows:—The bed plate of the machine is formed with a gudgeon, which fits into and can be adjusted to any position in a socket formed in or on a clamp which can be fixed on any part of the wrought-iron bar or column, thus forming a universal joint. This bar can be placed in position either horizontally or vertically, as may be most convenient, but it is generally placed across the level, against the sides of which it is screwed by means of the clamp and adjusting screw and claws. If necessary, wooden wedges are driven in between the claws and the wall to make it still firmer. The weight of the bar is about 120 lb.

The machine being thus placed in position, about a score holes, on an average of from 20 to 24 inches deep, are bored, one after another, over the area of the forebreast at an average rate of about an inch per minute in ordinary ground, which would cost about 4*l*. 10*s*. per foot to be driven by hand labour.

The machine is then removed and the holes charged with dynamite or tonite, and fired three or four at a time, those nearest the bottom being generally fired first, so as to make an advantage for those above them. The time occupied in boring, charging, and firing twenty holes and removing the *débris* is generally about ten hours. Two men and a boy work in a core, one being employed in attending to the machine, turning the borer and regulating the feed, another in squirting water from a flexible tube into the hole to remove the sludge, and the third in clearing away and throwing back the stuff that is broken. The work actually done at Dolcoath mine by the machine the first six months it has been working is 30 fms. 3 ft. 9 in. In the level exactly over that at which the machine is at work, and in ground of precisely similar hardness, the distance driven by hand labour was 30 fms. 3 ft. 2 in. in twenty-two months, or a monthly average of 1 fm. 2 ft. 4 in. against 5 fms. 0 ft. 7½ in. for the machine, showing that the machine has driven regularly nearly four times as fast as is practicable by hand labour.

The foregoing results, however, are by no means the only success achieved by the Barrow drill. For some time past its use has been rapidly extending in the hæmatite iron districts of Cumberland and Lancashire, the average rate of driving being, as in the instance quoted, estimated at four times that of hand labour, and in nearly every case at a saving of cost of at least 20 per cent.

An advantage, and by no means unimportant, is the improvement in the ventilation caused by the current of compressed air escaping from the exhaust of the machine, and the lowering of the temperature consequent on its expansion. This is noticeably the case at Dolcoath, where the machine is worked, the difference of temperature when the machine is working and when it is idle is very marked.

From the considerations mentioned at the commencement of these remarks, and judging from the results steadily achieved during the last six months, as well as from the unanimously favourable reports from competent men who have inspected the drill at work, there is every reason to consider the Barrow drill as the most successful machine of the kind yet put to work, and there is every reason to believe that its success at a large hard-ground mine like Dolcoath will lead to its early and general adoption in mining enterprise, and it becomes an accomplished fact that another triumph has been added to the long list of those achieved by mechanical science.

The cost of the machine is 65*l*., including patent rights; the 2-in. air pipes cost 3*s*. 3*d*. per fm., air compressor 70*l*. The estimated cost of two machines, air compressors, and 300 fms. of pipes, would be about 400*l*. See TONITE.

Borings, Deep, and Deep Mines.—The following statement of depths of borings and of mine shafts is from a paper on this subject, submitted to the Geographical Society of Glasgow by D. C. GLEN.

'The depth of the Artesian well at Grenelle, near Paris, is 1,798 ft., and the bore passes into the gault formation. It yields 476 gallons of water per minute, the water rising to height of 32 ft. above the surface, and the temperature is 81¾° Fahr. The well in Trafalgar Square, London, is 393 ft. deep. It descends into the upper chalk. A bore hole for exploring the coal measures at Creusot, in France, by Herr KIND, is 920 mètres, or 3,020 English feet, in depth. The deepest bore yet made is in Prussia, at Sperenberg, 22 miles south of Berlin. It has reached the great depth of 4,172 ft., and cost 8,717*l*., or about 43*s*. per foot. The deepest coal pit in Scotland is the Victoria pit, at Nitshell, where the Hurlet coal is worked at a depth of 175 fms. or 1,050 ft. The Monkwearmouth pit, near Sunderland, was for many years the deepest in England. It is 300 fms. or 1,800 ft. deep. Another pit, lying more towards the dip of the coal field, is a few fathoms deeper. The deepest pit in England is now at Dukinfield, near Manchester, belonging to Mr. ASTLEY. Its depth is 408 fms. or 2,448 ft. It passes through twenty-two workable seams of coal. The deepest pits in the world are now in Belgium, in the coal fields lying between Mons, Charleroi, Namur, and Liége. The shafts in several cases are over 750 mètres in depth, or 2,460 ft.; and one shaft at Gilly, near Charleroi, is 1,040 mètres deep, or 3,411 ft.; and one part has now reached the depth of 3,480 ft.

'The following table gives the depths and situations and nature of the deepest mines on the Continent.

Country	District	Nature of mineral	Name of pit or mine	Depth Feet
Wurtemburg	Jagstfeld	Salt	Friedrichshall	544
Russia	Turjinsk	Copper	—	696
Bavaria	Stockholm	Coal	Max	849
Portugal	Pallal	Copper	Taylor	1,070
Baden	Hagenbach	Coal	—	1,082
Pays-Bas	Kerkrade	Coal	Wilhelm	1,092
Sweden	Bersbo	Copper	—	1,377
Italy	Gavarrano	Lignite	Monte Masio	1,443
Spain	Granada	Silver	La Luerti	1,548
Hungary	Schemnitz	Gold and silver	Amalia	1,771
Norway	Kongsberg	Silver	—	1,869
France	St. Chaumont	Coal	St. Luc	1,976
Prussia	St. André	Silver	Samson	2,592
Saxony	Zwickau	Coal	—	2,637
Belgium	Gilly	Coal	Viviers	2,820
Austria	Birkenberg (province of Przibram)	Silver and lead	Adalbert	3,280

For the depth of British mines, see MINES.

BRASQUE. At the lead and silver works of the Upper Hartz, a compound, of one part of powdered clay slate and two of small charcoal, is used in the furnaces and called 'brasque.' The name is usually given in the German works to charcoal, coke, graphite, or anthracite in powder, mixed with clay or powdered clay slate.

BRATTICE CLOTH. Under ordinary circumstances the brattice cloth used in mines is a very stout variety of canvas, often thoroughly impregnated with carbonaceous matter. At a meeting of the Manchester Geological Society, Mr. W. H. JOHNSON described a new kind of brattice cloth, composed of *wire cloth*, in which there were about 36 holes to the inch, and the wire was almost as fine as any iron wire could be. This cloth would, it was thought, be more durable and less liable to burn than the common cloth. It was, however, suggested that the common brattice cloth saturated with alum would do as well. This could be effected and the fire-proof cloth produced at a cost of about 7*d.* or 8*d.* per yard, whilst the wire cloth would cost about 4*s.* the yard.

BRAZILETTO or **BRAZILETO.** The common name for *Cæsalpinia*, also specially the colonial name for *Cæsalpinia Brasiliensis*. The wood of this tree affords a beautiful dye. It furnishes the *Sappan wood* of commerce, and the Bukkum or Wukkum of India. See DYE WOODS.

BRAZILIN. (Vol. i. p. 476.) This colouring matter may be prepared from the dark brown red crusts consisting of brazilin and a lime brazilin lake, together with mechanical impurities, which are deposited during the preparation and storage of commercial extract of Brazil wood.

These crusts may be boiled with water acidulated with hydrochloric acid, and the brazilin which separates from the filtrate on cooling purified by recrystallisation.

Pure brazilin is colourless and gives with deaërated water colourless solutions, which imparts a weak colour to mordanted cotton. By contact with air these solutions acquire a reddish yellow colour, and a nincreased tinctorial power. See RESORCIN.

BRAZIL WOOD. Used in colouring wine, and its detection. See WINES.

BREAD, VIENNA. (Vol. i. p. 476.) Professor HORSFORD, of Cambridge, Mass., has published, through the Government Printing Office, shortly after the Austrian Exhibition of 1873, an elaborate report on the methods employed in the manufacture of bread in Vienna. He describes the characteristics of the grain, the art of milling, the making of a yeast bread, and the processes in use in the Vienna bakeries. The unusual excellence of the Vienna bread, arising for the most part from the marked superiority of the Hungarian wheat and flour, is considered to be due, not so much to the constant care of the farmer in changing the varieties grown when the slightest deterioration of the quality of the product is detected, as to the dryness and clearness of the atmosphere of the district where the wheat is grown, at the time when the contents of the berry are in the condition technically known as 'milk.' So dry is the air in the Hungarian lowlands that there is no dew during the summer night; soon after sunrise the temperature rises to 74°–77° Fahr., and in the course of the day attains to 95°–140° Fahr., remaining at that temperature till nearly sunset. The driest months are July and August, the Hungarian summer being uniformly very dry. For testing the qualities of the flour, Professor HORSFORD states that the whole

of the nitrogenous substances can be separated from the starch by treatment with dilute acetic acid, and their amount estimated, after the settling out of the starch, by determining the specific gravity of the solution. This appears, however, to be a facile but insufficiently accurate means of arriving at the result. With reference to the pressed yeast employed in the manufacture of the 'Kaiser-Semmel' (imperial wheat bread), the following figures give some idea of the development of this branch of industry during the last thirty years. One firm alone sold, in 1846, 72,400 Zollver. lb., and in 1872, 3,170,000 Zollver. lb. The problem why bread becomes stale was attacked many years ago by Boussingault, who found that it did not necessarily lose weight by the evaporation of water, but he could arrive at no satisfactory explanation for the change. Professor Horsford believes that the gluten of the crumb walls of stale bread, which are stiff and brittle, is dehydrated by the heat of rebaking, and the water of hydration driven out softens the glucoid horny starch which coats and permeates the gluten. Thus softened, the crumb is more palatable, because it is in a condition to be dissolved by the saliva, and tasted. On cooling, the water is withdrawn from the starch, which is thereby rendered stiff, and restored to the gluten, and the bread becomes stale. By adopting the methods described in this report, bread of as good quality as that baked in Vienna may be produced in any country provided equally good flour is used.

BREWING. (Vol. i. p. 508). *Malt, Substitutes for, in Brewing.*—There are many farinaceous substances which, when added to malt and properly treated, yield a good beverage.

The quantity of starch obtained from an acre of potato plants amounts to three or four times that of barley, whilst the starch obtained from rice and maize amounts to at least double the quantity.

There is a prejudice against the use of maize in brewing; this arises from the fact, that comparative experiments have shown that maize wort containing one-third of starch attenuates in the same time more than ordinary wort, and in proportion to the degree of fermentation gives a larger yield of yeast than normal beer, and that this yeast is poorer in nitrogen, and becomes useless after a second treatment.

Beers brewed with an addition of starch are strong, pale, and good in taste, so long as in their preparation pure fresh malt yeast is used. Prepared potato slices cannot give a good tasting beverage, purified starch or starch sugar are necessary.

That maize may be used for brewing it requires peculiar treatment, on account of the peculiar quality of its kernels and the composition of its ingredients. It requires during malting a higher temperature than any other grain, to secure the separation of the horny shell from the mealy body. It requires also more time for dissolving.

The kernels of maize are surrounded by firm cells which prevent the dissolving action, and therefore the maize must be either powdered or soaked and boiled in water containing sulphuric acid, before it is mixed with the malt. Beers treated with potato starch ferment very strongly, but the fermentation of maize beer is slow and regular. These beers do not settle easily, but after settling they become strong.

The chemical composition of decoctions of worts of different kinds is as follows:—

Constituents of the wort	Pure malt wort	Maize malt wort	Rice malt wort	Starch malt wort
Sugar	4·00	4·08	4·84	4·67
Dextrin	6·05	6·63	6·35	6·00
Extract	12·29	12·27	12·30	12·32
Protein bodies	·63	·78	·66	·42
Other substances	·40	·58	·45	·43
Polarization, Soleil degrees	+130	+138	+132	+136
After the principal fermentation.				
Fermented Worts				
Alcohol	2·71	2·76	2·00	3·19
Sugar	1·05	1·12	·98	·35
Dextrin	4·54	4·31	4·42	4·74
Extract	6·50	6·48	6·25	6·01
Protein substances	·43	·39	·33	·28
Other substances	·57	·66	·62	·64
Polarization, Soleil degrees	+72	+68	+65	+69

The fermentation was found to be the quickest in the rice malt wort; that in the maize malt the slowest.—'Substitutes for Malt in Brewing,' by J. HANAMANN, *Fühling's Landw. Zeitung*, 1875.

F. ZWEERLIKAR ascertained how the nitrogen in barley becomes divided among the various products obtained in the brewing process. The percentage compositions of the results obtained were as follows:—

Substances	Nitrogen (dry at 100°)	Moisture	The moist substances contained	
			Nitrogen	Albumen
1. Barley	1·605	11·30	1·423	8·990
2. Barley soaked	1·252	41·11	0·737	4·606
3. Malt	1·694	10·20	0·521	9·637
4. Malt	1·694	42·00	3·072	6·191
5. Malt sprouts	3·579	14·48	2·061	19·497
6. Dust	2·074	13·57	0·570	16·371
7. Malt dough	5·506	82·05	0·989	6·301
8. Returns	3·001	75·83	1·762	4·853
9. Hops	2·053	11·05	0·826	11·650
10. Hop returns	2·799	77·18	0·639	4·067
11. Cooled lees	5·300	77·65	1·190	7·578
12. Yeast	8·130	76·47	1·013	12·185

Another table is instructive in connection with the above—

	Residue of Extract	Nitrogen in Extract	Nitrogen in Liquid	Albumen in Liquid	Alcohol in Liquid
Water after soaking	0·118	1·456	0·0017	0·0108	—
Unhopped wort	12·251	0·993	0·122	0·774	—
Hopped wort	12·622	0·921	0·116	0·741	—
Young beer	5·620	1·485	0·083	0·530	2·75
Lagerbier	5·427	1·217	0·066	0·420	3·23

The nitrogen of raw barley has to be divided as follows:—

Total weight of substances	Materials, Products and Residues	Nitrogen	Weight of Nitrogen	100 parts of nitrogen in barley correspond with
pounds		per cent.	pounds	per cent.
3125·00	Raw barley	1·4230	44·403	100·00
46·87	Skimmed barley	1·4230	0·667	1·50
9800·00	Water used	0·0017	0·160	0·38
108·00	Malt sprouts	3·0610	3·300	7·43
15·00	Dust	2·5700	0·463	1·04
2926·00	Wet returns	0·7620	22·313	50·18
500·00	Wet dough	0·9800	4·947	11·12
150·00	Wet cooled lees	1·1900	1·785	4·01
120·00	Wet hop returns	(0·639)	[2] 0·219	0·49
162·00	Wet yeast	1·9130	3·099	6·97
8670·00	Lagerbier	0·0660	5·722	12·87
			1·778	4·01

[1] 'Division of the nitrogen of barley amongst the products of Brewing,' by F. ZWEERLIKAR, *Dingl. polyt. J.*, abstracted in *Journal of Chemical Society*.

[2] Thirty lb. of hops contains 0·347 lb. of nitrogen. 120 lb. of hop returns, however, contains 0·766 lb., viz. 0·219 lb. more than hops, which difference must be added to the nitrogen amount in barley.

BRICKS. (Vol. I. p. 519.) LIDDELL's new improved and patented double brick-making machine, which is here illustrated (*figs.* 2266, 2267), deals with the moulding of bricks, and appears to be a considerable improvement on previous

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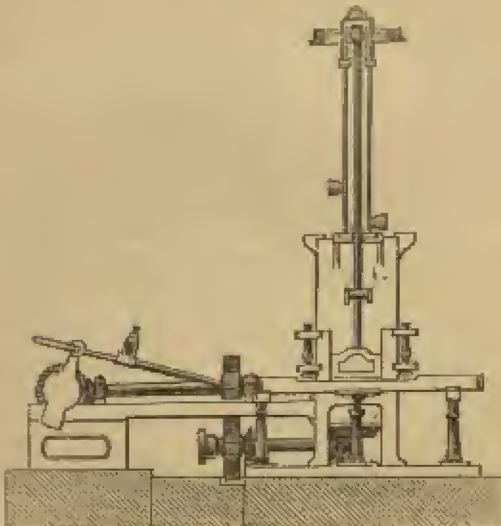

machines. It is driven from the main shaft, upon which is a bevel pinion gearing with a bevel wheel fixed to the lower extremity of the vertical shaft. The lower end of the vertical shaft is supported in a step or socket, whilst the upper end is carried in bearings formed in the beam, which beam also serves to bind together the side frames standing upon the upper part of the pugmill. Any required number of the ordinary pugmill screw blades are fixed upon the shaft, so that when the shaft is caused to revolve in the pugmill the screw blades mix or stir, and at the same time force the clay out of the pugmill into the brick moulds formed in the slides. The pressing blocks (one being situated on each side of the machine) are actuated from a cam at the upper end of the shaft. Guides are carried on the frames, and in the guides slots or slide beds are formed, slides being placed therein. Upon the slides antifriction rollers are situated in such position as to be acted upon by the cam, which, when revolving, causes the slides to rise and fall in the guides, and the pressing blocks being connected to the slides by the rods, they are thereby raised and lowered. When the clay has been thus forced by the pressing blocks into the moulds formed in the slides, the slides are moved so as to bring another mould opposite to and below the pressing blocks, which are then again lowered upon the clay, at the same time the brick last made is being forced out of the mould by one of the pressers which are actuated from a cam fixed upon the shaft. Weights are attached to the pressers, and to the

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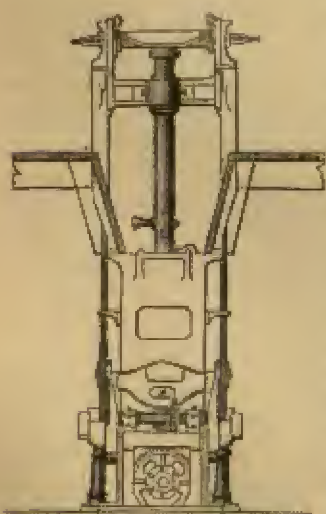


weights rods are fixed, their lower ends sliding vertically in guides situated at right angles to the rods, the inner extremities of the rods being provided with antifriction rollers, which bear upon the cam, so that by adjusting the cam on the shaft, the pressers may be made to fall at the proper intervals for removing the bricks from the moulds.

This machine is less liable to breakage, being more than a half heavier, consequently much stronger in all its different parts, than most machines. It has also only four bevel wheels, while other machines of a similar construction have no less than ten, which, with their attendant shafts and brackets, often become a total wreck, simply through a stone or any other hard substance getting into the gearing. The strain on the amount of gearing in these is very great, and either causes the shafts to jump, or wrecks the machine. In Mr. LIDDELL's machine the connecting rods are so fitted with safety springs that should any stone or piece of iron get into the slides the springs allow the connecting rods to pass, and thus prevent injury, and when the impediment is removed this machine resumes it work with little or no trouble. It is compact, simple, and complete in its construction, and all the principal parts can easily be got at for repair, and will turn out from 27,000 to 30,000 bricks per day. The engine required to drive it is one of 14 inches cylinder with a 30-inch stroke.

The following description of a steam brick kiln is abstracted from a paper read before the Franklin Institute, in January 1876, by Dr. HENRY W. ADAMS:—

'The object of this paper is to describe a new and improved process of burning a kiln of bricks, uniformly hard, without a salmon brick, or a blackened, or a glazed brick in the kiln, and in one-half the time, and with one-half the cost for fuel, now required. Bricks may be made by any of the known processes, but they are then only pieces of mud, and are not, in this condition, merchantable. They must be burned in order to be of any value. The comparative value of a brick made from our beautiful clay depends upon its hardness and the brightness of its deep red colour. To develop these qualities a high, sustained, and uniformly distributed heat is necessary. Such a heat cannot be secured in the old kilns. The outside walls absorb a large portion of heat, and thus rob the bricks next to them of the heat necessary to burn them hard. The heat, ascending from the fires, passes freely from the top of the kiln into the air, and is largely wasted. Hence more fuel is used to burn an old kiln than is needed if it could be properly distributed and utilised. When the fires are first fed with coal the gases generated fill the top of the kiln more abundantly, and raise the temperature of the bricks; soon the coal cokes, and the production of incandescent gases, rising through the kiln, is diminished. The superincumbent air, now no longer lifted from the top of the kiln by the ascending gases, settles down upon and insinuates itself between the top courses of the kiln, and cools them. Thus the top and sides of an old brick kiln produce a large quantity of salmon bricks. These bricks are worth about seven dollars per thousand. They average about one-fourth part of the kiln. It costs just as much to dig the clay, to temper it, to mould and dry these bricks, and set, and burn, and handle them, as it does to make hard stretchers and paving bricks, which are worth from 16 to 20 dollars per thousand. Besides, in a kiln as usually constructed only a small number of bricks can be burned in the heart of the kiln. The arches, from necessity, are overburdened in consequence of prolonging the firing sufficiently to burn the top and sides of the kiln into respectable salmon. This is a fair statement of the case. The practice and skill of generations have failed to remedy these defects.

'To burn any kiln of bricks uniformly hard, and of a deep red colour, three things, at least, are necessary:—

'1. The necessary quantity and degree of heat must be ensured.

'2. This heat must be equally distributed to and surround every brick in the kiln for the same length of time.

'3. This heat must be held in the kiln, under a pressure greater than the outside air, so as to cause it to fill the entire honeycomb of the kiln, and wrap every brick, and burn the top and sides as quickly as the bottom.

'If these conditions can be realised in a kiln, it is easy to see that a uniform result will be obtained. But, to do this, it is necessary that the kiln should be an oven. The heat must be made outside of the kiln proper, and driven into and under it by forcible jets of steam, in order to fill the kiln with the necessary heat under pressure. The top must be banked down by at least two platting courses of burned bricks to hold in the heat. In the old kiln the draught is shut off by closing up the top tightly; but in the new kiln this is not required, because no dependence is placed on the natural draught.

'For three or four hundred dollars an old brick kiln can be converted into one suited to the new process. Take, for example, a ten-arch kiln built in the old style. To alter this, take out the grate bars and widen the ash pits to the width of 2 ft., and

then an arch over each, composed of fire bricks, and filled with pigeon-holes about 3 in. square, to let the heat through under the whole bottom of the kiln. The floor of the kiln is levelled off, and the bricks to be burned are set directly on this floor, without arches. The kiln is set in the usual manner, and two platting courses of burned bricks are laid down on the top platting course of green bricks. They are left loose enough to let the water and smoke escape, then tightened down when it has gone. The fire-places are built in front of the old fire doors, on the outside of the kiln, and the grates in these furnaces are 4 ft. long and 3 ft. wide, and are on a level with the old ash pits, so that the products of combustion are driven into the permanent and pigeon-holed arches under the bottom of the kiln. Jets of steam, escaping from nozzles $\frac{3}{16}$ths of an inch in diameter, are let into the furnaces, over the fire doors, under a pressure of about 65 lb. to the inch, sweeping over and across the burning fuel. They make a partial vacuum in the furnace next to the fire doors, and draw up large volumes of air to intensify the combustion. No smoke is left unconsumed. The white hot gases and superheated steam are forced under the whole bottom of the kiln, and made to pass up through the pigeon-holed arches, and thence through the bottom of the kiln, and fill the interstitial spaces between the bricks.

'The top platting courses being now closed up tight, the kiln becomes an oven, filled in every part with a uniform heat. A partition is placed in the middle of the length of each arch to prevent the two opposite blasts from acting against each other. The steam is superheated at the expense of the overheated arches and bottom of the kiln, and becomes a carrier to lift up the heat and circulate it through the upper parts of the kiln. To cheapen the cost for fuel and to produce a large volume of flame to help forward the process of burning and colouring the bricks, the kiln is surrounded with a half-inch pipe, from which branches, a $\frac{1}{4}$ of an inch in diameter, lead and look over an inch hole through the top of each furnace, to allow a small stream of crude petroleum, about as large as a needle, to fall down on to the red hot coals and burst into flame. The jet of steam shooting over the fire door and through the furnace draws in air, and produces the most intense combustion, and supplies the entire bottom of the kiln with an abundance of heat of the highest and most uniform intensity. This great source of flame and gases enables the use of cheaper fuel and the substitution of fine instead of ordinary coal. The grates are plates of cast iron, 4 ft. long and 2 ft. wide, perforated with small round holes, about $\frac{3}{8}$ths of an inch in diameter on the upper side, and $\frac{1}{2}$ an inch wide on the under side, to let the ashes fall through without clogging. The fires are kindled with wood and large coal at first, and then the fine coal is gradually thrown on, and kept about a foot thick. The small stream of petroleum falling on to this red hot bed bursts into flame, and the forcible jets of steam draw in the air for perfect combustion, and nothing can exceed the economy, regularity, and perfection of the heat thus produced.

'It is this perfect regularity and continuity of the heat produced by the furnaces which render the burning of the kiln so easy and so perfect. There is no danger from the use of petroleum in this manner. Explosions can never take place with any hydrocarbon without an admixture, with its vapour, of atmospheric air or oxygen. When stored in air-tight pipes it is just as safe as water.

'It now costs from 275 to 300 dollars to burn a kiln of 200,000 bricks, while in the same sized kiln by my process every brick can be burnt, and burnt hard, for 110 dollars, or 55 cents per thousand.'

So far as we know, Dr. ADAMS was the first who ever used steam in a brick kiln, to be superheated by the excess of heat in the arches and bottom of the kiln, and to circulate this heat and distribute it in the upper parts of the kiln. His first patent for this use of steam was dated July 21, 1868. When this patent was examined by the United States Patent Office it was found that the word 'steam' had never been used in connection with a brick kiln in the world. This patent was taken out in 1868, in nearly every country in Europe. In the specification of the American patent, it says: 'The life of my invention consists in a new method of producing, distributing, transporting, and retaining the necessary heat, in all parts of the kiln, so as neither to overburn the bottom or underburn the top, but to equalise the heat of both by means of a positive, and reliable, and instantaneous power, and to supply any desirable degree of heat to all parts of the kiln alike. This I accomplish by the accurate and positive manner of introducing air and steam into the fire-places, the former to promote perfect combustion, and the latter to become superheated, at the expense of the overheated fire-places and bottom bricks, and both to carry up caloric to be distributed and utilised in raising the topmost courses to a setting heat.'

Another patent was dated July 20, 1869, and covered some additional details such as the building of the fire-places outside of a brick kiln, and the forcing of the products of combustion into the kiln by jets of steam. Amongst the claims was one allowed in this patent for the use of steam, and is in these words:—'The arrange-

ment of furnaces in a brick kiln, with jets of steam discharging into the furnaces, substantially as and for the purpose set forth.' These patents were parted with soon after they were issued, but the parties holding the right so modified the disposition of the fires and introduction of the jets, that their kilns never worked satisfactorily, and the patent was generally regarded as a failure. Had the kiln been arranged as patented, with an upright draught, its success would have been perfect at the start. The control of the original patents has now reverted to the patentee; and with a new patent, dated November 23, 1875, there is secured every useful detail which experience has shown necessary to make the invention all that can be desired.

To show that these statements are supported by actual accomplishments, it may be stated that four kilns have been burned off this last autumn, (1876), with the upright draught, in accordance with the patents. These were small kilns, and were built at the Fish House Station, near Camden, by Mr. RICHARD D. COX, on the yard of Mr. REEVES. All four of these kilns were burned in half the ordinary time, and every brick was perfectly hard. The last kiln was left standing for exhibition, full of bricks just as burned off. There was not a brick in this kiln, including the top platting courses, but which is hard stretcher. It settled 13 inches, and was burned in just 49 hours by a man who had never burned a kiln of bricks in his life.

A further corroboration of these statements will be found in the fact that Professors J. P. COOKE, jun., and E. N. HORSFORD, of Harvard University, examined and reported favourably on the operation of the process, while the MASSACHUSETTS BRICK COMPANY, of Cambridge, near Boston, have put the kilns into operation with great success. When we consider that 1,000 bricks is required to each 7 or 8 inhabitants of our cities per year, and that over a dollar per 1,000 in price and a dollar per 1,000 in quality is saved by the new kilns, the magnitude and the value of this improvement is made comprehensible to the minds of all.—*Journal of the Franklin Institute*, March 1876, Vol. lxxi, No. 3.

J. D. PINFOLD's brick making machinery has excited much attention. Mr. PINFOLD is well known as of Rugby, and celebrated for his brick machines. The general principle of his arrangement will be understood from the following description:—

The clay in its rough state having been drawn up by the hoisting gear or otherwise brought to the machine, is fed into a massive pair of grinding rolls, which thoroughly crushes it and all it contains. The arrangement for adjustment is very simple, and at the same time very effective, inasmuch as the contrivance for setting the distance of the rolls apart also answers the purpose of a safety apparatus, so that in the event of a piece of iron or other foreign substance harder than ordinary pebbles or small stones getting between the crushing rolls no harm can result to the machinery. This is a great improvement over the majority of crushing mills at present in use. The ground clay then falls from the crushing rolls into the pugmill, which is fitted with a very strong wrought-iron shaft, to which is attached a series of strong wrought-iron blades and driven by correspondingly strong wheels, so as to enable the use of the clay in the stiff condition necessary for making good sound well shaped bricks. After having been thoroughly mixed in the pugmill, the clay is fed by it into the compressing rolls, the action of these rolls is such that while they push the clay towards the die they expel every particle of air, and thereby prevent the loss of bricks from the expansion of air during burning. The easy issue of the clay is provided for by a suitable steam or water lubrication. The clay is now a rectangular block only requiring to be cut into the required thickness.

The cutting table is very ingenious. In most other cutting tables in use, either the travelling of the clay has to be stopped, or a piece of it has to be cut off from the travelling stream by a preliminary cutting wire, and afterwards operated upon; but in this machine the bricks are cut with perfect accuracy—while travelling—from the continuously advancing stream of clay without the use of any preliminary cutting wire, thereby doing twice the amount of work at half the usual cost. The bricks, after they are cut off, are delivered either on to a special bearing-off barrow, ready for wheeling away, or are put on to the inventor's patent separators, so that the bricks may be carried to the drying stoves and mechanically parted without any separate handling.

This machine is said to make from 20,000 to 30,000 first-class solid bricks per day of ten hours, the quantity being regulated by the industry of the men employed; the labour required to make the former quantity is three men in the mine, one at the top of the incline, one to work the cutter and load the barrows, and three men and three boys to wheel away and pile the bricks in the kiln.

These machines will produce either solid or perforated brick moulds, or drain tiles, or anything that can be expressed from a die. The clay used in this machine is so stiff that the bricks may be stacked at once for drying six or eight high without injury to their shape.

Bricks are sometimes made on the Continent of highly silicated viscous slags, especially such as results from the lead smelting furnaces. They are used for constructing those parts of the furnaces in which very high degrees of temperature are not produced. See FIRE BRICKS.

BRIMSTONE. See SULPHUR, PYRITES, &c.

We have *Imported* brimstone as follows:—

	1871		1873	
	Cwt.	Value	Cwt.	Value
From Belgium	7,021	£3,890	22,743	11,680
" Italy . . .	1,031,414	345,673	1,089,194	373,733
" other Countries . .	5,651	1,893	5,797	2,049
Total . . .	1,044,116	351,665	1,117,734	387,462

This does not include the enormous quantities of sulphur obtained from the pyrites, which we import from Spain, Norway, &c.

BROMINE. *To detect by the Blowpipe.*—If insoluble, the *bromide* is fused before the blowpipe flame, with two or three volumes of carbonate of soda. A soluble bromide is thus formed with separation of the base. If this fused mass be dissolved and filtered, and a small quantity of nitrate of silver be added, a bromide of silver is precipitated. This is fused with bisulphate of potash in a test tube. The bromide of silver will quickly separate from the flux in the form of a blood-red globule, which becomes pale yellow when cold; when placed in the sunshine it will, after a short time, turn green.

Chloride of silver treated in the same way turns rapidly to a dark grey in the sunshine. Iodide of silver retains its colour.—CHAPMAN.

BROMINE, *Its use in Hydro-Metallurgy for treating Ores of Mercury.*—R. WAGNER (*Bulletin de la Société Chimique de Paris*, February 5, 1876) states that, according to the official returns from India, in reverberatory furnaces used for the reduction of cinnabar, 48 per cent. is lost, and in the best muffle furnaces 10 per cent. He therefore proposed the wet process. This plan is to digest the ores of Idria and of Deux Ponts with bromine water, containing 3 per cent. of bromine, or with 13 per cent. of solution of bromine in hydrochloric acid.

After digesting the cinnabar with an excess of the bromine liquid for a few days, the whole is dissolved, as is also any metallic mercury present. From the solution the mercury is thrown down by means of sulphuretted hydrogen, and the sulphide of mercury is dried and decomposed. The amount of bromine required is very considerable, for 1 part of mercury obtained 3½ parts of hydrobromic acid remaining in solution. The process is therefore only applicable where the manufacture of bromine compounds can be combined with the extraction of this mineral.

BRONZE, MANGANESE. This is an alloy of copper, or one of the ordinary bronzes, and manganese, which is claimed by Mr. PARSONS in a patent of February 7, 1876. It appears, however, to be of a much older date, since we were shown specimens, said to be this alloy, in Birmingham, at least twelve years since, and we learn that Dr. PERCY made it, and that it was submitted to the German silver manufacturers, as the alloy of nickel, without their detecting the difference.

Mr. ALEXANDER PARKES writes, in answer to my enquiry:—

'I have many patents for the manufacture of manganese alloys dating through many years, from 1848 up to last year, from which you will see my mind has been engaged on these manganese compounds for more than twenty-eight years; and I have made sheets, wire, rods, tubes, nails, castings, spoons, and forks, and even a 4-lb. cannon, which was cast solid, forged at a red heat, bored, finished, and proved with an excessive charge of powder, and double shotted, at the Birmingham proof house more than twenty years ago. My first patent for manganese alloys was taken in the joint interest of Messrs. ELKINGTON, MASON, and myself in the year 1848.'

This compound metal is now made under the above patent by the 'WHITE BRASS COMPANY,' and is introduced to the public as 'PARSONS' Manganese Bronze.'

The following account of some experimental trials proves the very remarkable properties of this alloy:—

This new alloy is termed 'Manganese Bronze.' It is composed of any ordinary bronze combined with manganese, which it appears has the effect of cleansing the metal of all oxide, and rendering it very homogeneous and close grained, even a good sized ingot presenting a fracture as fine and close grained as a piece of steel; the metal also possesses increased strength, toughness, and hardness, which latter

quality can be increased very considerably. In colour it resembles good gun metal, but is of a rather brighter and more golden hue. It can be forged at a red heat and rolled into rods or sheets and drawn into wire and tubes. The best results are obtained by using spiegeleisen or ferro-manganese in varying proportions, according to the requirements of the bronze. See Spiegeleisen.

The ferro-manganese used with gun metal should be richer in manganese than that used with brass alloys, while that used with the bronze alloys may be between the two and regulated as conveniently as can be by the proportions of tin and zinc employed. If little zinc is used in the bronze alloy the ferro-manganese employed may be as rich or nearly as rich in manganese as in the gun-metal alloys; while if the zinc predominates the ferro-manganese employed may be the same as or a trifle richer in manganese than that used with the brass alloys; and if the zinc and the tin are about equal, the quantity of the manganese contained in the ferro-manganese may be between that used for the gun metal and that used for brass alloys.

The ferro-manganese used to mix with the gun-metal alloys should contain from about 10 to 40 per cent. of metallic manganese, while that used to mix with the brass alloys should contain from about 5 to 20 per cent. of that metal, and that used for the bronze alloys should be between the two, according to the proportions of tin and zinc employed.

In selecting the ferro-manganese it is desirable that it should contain as little silicon as possible; when spiegeleisen can be obtained of the best quality containing but a minute quantity of silicon and from 5 to 10 per cent. of manganese it will be suitable to mix with the brass alloys, and it may even be used with the gun-metal alloys.

Ferro-manganese as now manufactured for, and used in, steel works, rich in metallic manganese, containing say from 50 to 60 or even 70 per cent., should be melted in a crucible under powdered charcoal, along with the requisite proportion of the purest wrought-iron scrap, to bring down the quantity of the manganese to any of the proportions before named. Thus, supposing it is desired to employ a ferro-manganese to mix with any of the alloys containing 20 per cent. of manganese, a ferro-manganese containing 60 per cent. of metallic manganese, and say 1 per cent. of silicon, is melted with wrought-iron scrap in the proportion of 100 of ferro-manganese to 200 of wrought-iron scrap, and a ferro-manganese containing the desired quantity of metallic manganese (20 per cent.) will be obtained, containing only one-third per cent. of silicon, instead of 1 per cent., and so on for any other proportions required; not only this but a still further portion of the silicon is eliminated and the metal refined by the second melting in a crucible.

Six specimens of this *manganese bronze* were submitted by the White Brass Company for trial and tested at the Royal Gun Factories for tensile strength, elastic limit, and ultimate elongation. These consisted of three cast specimens of different degrees of hardness, and three from each of these forged at a red heat and drawn down from a cast ingot about 2¼ in. square to a round bar 1 in. diameter, afterwards turned to gauge for the testing machine ·533 in. diameter.

No. 1 cast—intended for construction purposes where strength and toughness are necessary—gave an ultimate tensile strength of 24·3 tons per square inch, with an elastic limit of 14 tons and an elongation of 8·75 per cent. No. 1a, forged from the same metal as No. 1 was cast from, gave a tensile strength of 29 tons per square inch, elastic limit 12·6 tons, elongation 31·8 per cent. No. 2 cast—rather harder than No. 1—tensile strength 22·1 tons, elastic limit 14 tons, elongation 5·5 per cent. No. 2a, forged from the same, tensile strength 28·8 tons, elastic limit 13·2 tons, elongation 35·35 per cent. No. 3 cast—still harder—tensile strength 22·6 tons, elastic limit 16·8 tons, elongation 3·8 per cent. There was a slight flaw in this specimen, which caused it to break with a less strain, and to stretch less than it would otherwise have done. No. 3a, forged from No. 3, tensile strength 30·3 tons, elastic limit 12 tons, elongation 20·75 per cent.

This appears to prove that No. 1 cast specimen is about equal in tensile strength and elongation to wrought iron of average good quality, while its elastic limit is rather higher, for scarcely any wrought iron will exceed ten or eleven tons, and all the forged specimens considerably exceed this, both in tensile strength and ultimate elongation.

When simply cast, even the tough qualities are harder than gun metal, possessing about double its strength up to the elastic limit, and about 50 per cent. more ultimate strength, while at the same time it will bear more bending and hammering, and the harder qualities intended to be used when pressure and friction come into play are considerably harder than gun metal. The forged specimens are about twice the ultimate strength of gun metal and forged yellow metal now generally used for bolts, &c.

The details of the process of manufacturing this metal are not yet made public by the White Brass Company. There is every reason to believe that it consists in adding metallic manganese in various proportions to selected varieties of ordinary bronze or

brass: certain it is that there is nothing occult about the process of manufacture, and that manganese bronze may be regarded as a commercial article. The commercial manufacture of manganese bronze makes a step in the science and art in metallurgy of no small importance.

We have been favoured by the WHITE BRASS COMPANY with two tables, giving the results of the experimental tests to which this new compound metal has been subjected.

Six Specimens of Manganese Bronze received from Mr. PARSONS, at the Gun Factory, Woolwich, tested to ascertain their resistance to Tensional Strain.

Diameter of Specimen, ·533 in. Length of Breaking Part, 2 in.

Register Number	Mark on specimen	Tons per square inch: Yielding	Tons per square inch: Breaking	Elongation in 2 in.	Remarks
4,766	1	14·0	24·3	·175	Cast in metal mould
4,767	1A	12·6	29·0	·036	" " and forged
4,768	2	14·0	22·1	·11	" "
4,769	2A	13·2	28·8	·707	" " and forged
4,770	3	16·8	23·0	·076	" " slight flaw in specimen
4,771	3A	12·0	30·3	·115	" " and forged

TABLE *showing the results of experiments on the transverse strength and toughness of bars of manganese bronze as compared with wrought-iron and gun metal, made by dropping a weight on the middle of the bar resting on supports at each end.*

Weight of monkey	60 lb.
Height of fall	5 feet
Distance between supports	1 foot
Dimensions of bars	1 inch square, 14½ inches long

PERMANENT DEFLECTION IN INCHES, IN THE LENGTH OF 12 INCHES.

No. of Blows	Wrought Iron, Staffordshire Rolled: No. 1	No. 2	No. 3	Gun Metal, Cast in Sand: No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	Manganese Bronze, Cast in Sand: No. 1	No. 2	No. 3	No. 4	Manganese Bronze, Forged: No. 5	No. 6
1	1·15 and broke half thro'	·60	·50	·92	·80	·90	·72	·72	·45 and broke	·66	·08	·68	·25	·29	·60
2	..	·97	·90	1·60	1·50	1·63	1·22	1·43	..	1·23	1·25	1·26	·99	1·06	1·10
3	..	1·61	1·45	1·70 and broke	2·22 and broke	2·33	1·92	1·63 and broke	..	1·73	1·73	1·77	1·37	1·44	1·44
4	..	2·30	1·87	..	..	2·86 and broke	1·94 and broke	..	..	2·16	2·18	2·22	1·70 and broke	1·90	1·91
5	..	2·74	2·53	..	..	..	..	..	..	2·62	2·00	2·71	..	2·19	2·10
6	..	3·20	2·80	..	..	..	..	..	..	2·96	2·63	3·10	..	2·45	2·49
7	..	3·71	3·27	..	..	..	..	..	..	3·47	3·09 and broke	3·62	..	2·77	2·70
8	..	4·20	3·80	..	..	..	..	..	..	3·93	..	4·25	..	3·08	3·13
9	..	4·84 not broken	4·33 not broken	..	..	..	..	..	..	4·02 not broken	..	4·54	..	3·62 not broken	3·40
10	..	..	..	..	..	..	..	..	..	..	..	4·92 not broken	..	..	3·78
11	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4·10
12	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4·40
13	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4·40 and slipped thro' supports

REMARKS.—*Wrought Iron.* The specimens were all Staffordshire iron. No. 1 was ordinary, No. 2 was best mitre, and No. 3 was best s.c. iron.

Gun Metal.—The specimens Nos. 1, 2 and 3 were of the qualities ordinarily supplied by brass founders, and used generally in the works of engineers and machinists; Nos. 4 and 5 were cast specially, and composed of copper 16 parts, and tin 2 parts; No. 6, of copper 16 parts and tin 2½ parts by weight, the copper best selected, and the tin best English.

Manganese Bronze.—The specimens Nos. 1, 2 and 3 were of No. 1 quality, intended for use where strength and toughness were required. No. 4 of No. 2 quality, for use where hardness, stiffness, and resistance to wear and abrasion were required. The forged specimens were of the quality supplied for bolts, nuts, forgings, &c., having strength, elasticity, and toughness. No. 5 was as it left the forge. No. 6 was annealed.

BRONZE, PHOSPHOR. (Vol. iii. p. 554.) Since the description given in the volume referred to was written, a considerable amount of attention has been given to the combinations of phosphorus with copper and bronze. Attempts have been made to prove that the cutting tools of the ancient Mexicans and Peruvians, which were generally of copper, and which were remarkable for their extreme hardness, were made from an alloy containing phosphorus. This appears somewhat doubtful; but it has been proved that the addition of a small percentage of phosphorus to bronze is capable of increasing its hardness to an extraordinary extent. And not only is the hardness of the alloy heightened by this admixture, but its power of resisting the repeated applications of strain is also greatly enhanced.

It appears, as the result of some experiments made in Berlin, that while a bar of ordinary bronze was utterly incapable of bearing a strain amounting to 10 tons per square inch, a bar of phosphor bronze bore this strain applied as tensile 408,230 times before giving way. A second bar of the same phosphor bronze actually withstood 147,850 applications of a load of 12½ tons to the square inch without fracture.

With regard to transverse strain, bars of phosphor bronze have been subjected to 1,260,000 deflections with a load of 9 tons per square inch without any signs of deterioration. The amount of phosphorus required to effect this change is only about ½ per cent.

This alloy in its application to rolling mills and for tuyères for blast furnaces was sent by the inventors, MM. MONTEFIORE-LEVI and Dr. KÜNZEL, to the Vienna Exhibition, and also a collection of models illustrative of its application in artillery. M. GILLIEAUX, of Charleroi, and M. BLONDIAUX, of the Thy-le-Château Society, have, from the first production of the alloy, employed it in the construction of rolling mills, and the following are the results of three years' experience:—

This bronze has been employed for the great bearings of plate and general rolling-mills, and for conical gearing in universal rolling mills. The motive power of the steam-engine that drives the rolling mills in which it is used, is of 170-horse power to 200-horse power, and the speed of the rollers about sixty revolutions per minute; the engine drives a sheet-iron mill, a universal mill, and a rough shaping mill, and is not at a standstill for more than an hour and a half in the twenty-four. The rollers are 1·90 millimètre long, and 0·62 millimètre in diameter, and weigh five tons. It was found that the gear, when made of hard cast iron, broke frequently; these were first replaced by wheels of ordinary bronze, and finally by phosphor bronze. The duration of ordinary bronze wheels did not exceed, on an average, five months, while those made of phosphor bronze wear for about nine months.

M. BLONDIAUX has applied phosphor bronze not only in the making of pinions, but in the driving axes of mills, with great advantage; in the latter case the superiority seeming to depend not in the hardness but in the very great resistance of the alloy, the arbres in phosphor bronze twisting much less than those made of forged iron, and not being liable to break like those of cast iron.

A great variety of objects hitherto manufactured in iron and steel are now cast in phosphor bronze, and in many cases they require only a polish to make them ready for use; besides which they do not corrode, as articles of iron or steel do. The great fluidity, compactness, and fine grain, as also the beautiful colour of the metal, recommends it for decorative art, and the perfection of the castings greatly reduces the cost of chasing and finishing. This alloy stretches more than copper or any of its ordinary compounds, and plates have been reduced, by a single cold rolling, to one-fifth of their thickness, the edges remaining perfectly sound and without crack.

By order of the Prussian Ministry of Commerce, experiments have been made with the various kinds of phosphor alloy, the object of which was to ascertain the resistance of the metal to repeatedly applied strains or pulls, and also to bends of a given force. The first bar fixed on the stretching machine resisted 408,230 pulls of 10 tons per square inch, while a bar of ordinary bronze broke before even the strain of 10 tons per

square inch had been attained. Another bar withstood 147,850 pulls of $12\frac{1}{2}$ tons per square inch. Still more favourable results have been obtained on a machine by which the test bar was bent as often as 40,000 times per day. In this instance it resisted 862,980 bends of 10 tons per square inch, while the best gun metal broke after 102,650 bends of the same force. Another bar which was being tested withstood 1,260,000 bends of 9 tons' force per square inch, without showing any signs of weakness.

It has been repeatedly stated that one great advantage of this phosphor bronze, was that it would not emit sparks. And we believe tools for the use of the gunpowder works have been made from it. It has, however, been proved that this alloy does emit sparks when subjected to sharp friction or violent percussion.

A series of conclusive experiments were made in one of the workshops of the Royal Gunpowder Factory, Waltham Abbey. These experiments were conducted after dark on the evening of October 26, 1874, in the presence of Colonel Younghusband, Major Majendie, Major Morgan, and others, but they have been published only recently.

During each experiment the gas was extinguished, leaving the room in total darkness, so that the least spark could be readily distinguished. The numerals distinguishing the different samples of phosphor bronze experimented with indicate different alloys, No. 2 being the softest and No. 8 the hardest, and the results are recorded exactly as they were noted down after each experiment.

The results obtained show that copper, gun metal, and phosphor bronze are all liable to emit sparks, or as it is commonly called, 'strike fire,' when subjected to a certain description and degree of friction, the degree of liability appearing to vary with the different alloys and frictional surfaces. So far as they went, these experiments appeared to indicate that the harder descriptions of phosphor bronze emit sparks less readily than the softer samples, and less readily than ordinary bronze, or even than copper. The negative results obtained in some examples can hardly be safely accepted as conclusively establishing the absolute non-liability of the various metals employed to 'strike fire' under the conditions described. With a slight variation of those conditions, it is not impossible that sparks would be obtained.

The real value of these experiments consists in the positive evidence which they furnish as to the somewhat unexpected readiness with which, under certain conditions, sparks, and even a stream of sparks, more or less continuous, may be obtained by friction from such metals as copper, gun metal, and phosphor bronze. This result can hardly fail to possess a practical interest for manufacturers of gunpowder and other explosives, and for persons who are called upon to deal with and handle these substances. At the same time, these experiments, as might have been anticipated, bear ample testimony to the very great superiority of copper, gun metal, and phosphor bronze to iron and steel, in regard to the liability to 'strike fire.'

In one Series, a 'free grit' stone of the same description as is used for sharpening small tools and razors, 6 in. diameter, revolving 1,320 revolutions per minute, travelling 2,073 ft. per minute, was supplied for these experiments, the material experimented with being in each case applied firmly to the revolving stone and held against it for about half a minute. The first experiment was with No. 2 phosphor bronze, which occasioned sparks, and sometimes a stream of them. In experiment 2 on No. 2, phosphor bronze, the sparks amounted to a small feeble continuous stream. In experiment 3, on a thin gun-metal knife it gave a few sparks, but no continuous stream, and nothing like No. 2. In experiment 4, on a gun-metal lever of stouter section and altogether harder than the knife, there were numerous sparks, and at times a slight stream, but not quite so bad as in No. 2. In experiment 5, on gun-metal ingot, for making bolts, &c., good casting, there were a few sparks, but chiefly a continuous feeble stream, but only the cast surface was applied (see No. 10). In experiment 6, on gun-metal ingot for making bolts, &c., but a rotten casting, there was a considerable uninterrupted stream of sparks quite as bad as in No. 2. In experiment 7, on No. 2 phosphor bronze, a feeble stream was at first obtained, but not so bad as No. 6. In experiment 8, being No. 7 repeated, one or two faint sparks only were obtained. In experiment 9, being No. 6 repeated, a continuous and lively stream of sparks was obtained, it being the worst result up to this point. In experiment 10, being No. 5 repeated, but applied only to the strictly metallic surface, there was a strong stream of sparks, occasionally interrupted, but generally continuous. This was about as bad as No. 9. In experiment 11, on No. 4 phosphor bronze, some very strong sparks were obtained, and at times almost a succession, but generally rather of the nature of a prolonged spark. In experiment 12, on No. 7 phosphor bronze, one or two strong sparks were obtained, but no indication of a continuous stream; in fact, less than in No. 11. (This is the alloy usually employed for the tools and fittings of gunpowder works where phosphor bronze is used.) In experiment 13, on No. 8 phosphor bronze, so hard that it can be used to chisel hard

bench, only one faint spark was obtained. In experiment 14, on gun-metal ingot, the same as employed in No. 10, a considerable succession of sparks was obtained, but not quite so bad as in No. 10. In experiment 15, on copper sheet, about $\frac{1}{8}$th of an inch thick, for press plates, &c., an intermittent stream of small sparks was obtained. In experiment 16, on gun-metal casting, for the edge of a press plate, 3 sparks were obtained. In experiment 17, on a wrought-iron rod, a bright continuous stream of fire was obtained, and the sparks flew 6 inches or more in some cases. The light was very bright and intense. In experiment 18, on hardened steel, being a file, there were brilliant coruscations.

In another Series, a cast-iron cylinder 6 inches in diameter, and revolving at 1,220 revolutions a minute, was substituted for the 'free grit' stone. In the first three experiments on Nos. 2, 7, and 8 of phosphor bronze there were no sparks. In experiment 4, on a gun-metal ingot, there were no sparks. In experiment 5, on a copper sheet $\frac{1}{8}$th of an inch thick, there were no sparks. In experiment 6, on a wrought-iron rod, there was a brilliant stream of fire. In experiment 7, on hardened steel, there was a brilliant and rapid flow of sparks. In Series C, a gun-metal cylinder, 8 inches in diameter, and revolving at 1,625 revolutions per minute, was substituted for the iron cylinder. In all the experiments, seven in number, conducted on Nos. 2, 7, and 8 phosphor bronze, on a gun-metal ingot, a copper sheet, wrought iron, and steel, there were no sparks.

To the above, as especially interesting, may be added a table, recently issued by the PHOSPHOR BRONZE COMPANY, showing the results obtained with experiments on axle bearings in Germany, and published in the *Polytechnisches Centralblatt* of January 1, 1877:—

Kind of Bearing	Composition in 100 parts alloy	Comparative cost of 100 kilos. bearings, inclusive of melting expenses, loss, &c.	1 kilo bearing Metal Runs: German Miles	Kilometres	Wear per 1,000 kilometres for 4 bearings	Cost of Bearing Metal per Waggon with 4 Bearings per 100 kilometres	Names of Railroads where used
		marks			grammes	sp. gr.	
Gun Metal	83 copper, 17 tin	200[illegible]	13,003	90,500	11[illegible]	0·300	Austrian Railway
"	82 copper, 18 tin	200[illegible]	10,820	80,000	10[illegible]	0·200	Grand Central Belge
White Metal	3 copper, 90 tin, 7 antimony	258[illegible]	9,104	73,280	14[illegible]	0·205	Austrian Railway
" "	5 copper, 85 tin, 10 antimony	[illegible]	11,750	88,140	11[illegible]	0·331	Niederschlesisch-Märkische Bahn
Lead Composition	84 lead, 16 antimony	118[illegible]	10,335	82,280	15[illegible]	0·163	Austrian Railway
Phosphor Bronze	.. ..	350	57,228	429,200	2[illegible]	0·084	Grand Central Belge
Gun Metal on brake cars	82 copper, 18 tin	200[illegible]	1,213	9,104	160[illegible]	2·844	" " "
Phosphor Bronze on brake cars	.. ..	350	14,320	107,410	9[illegible]	[illegible]	" " "

We must acknowledge our obligations to *Iron* (January 1, 1876) for the above report of the experiments with phosphor bronze and other metals.

At the phosphor-bronze works at Val-Benoit, Liége, pit ropes have been made entirely of this alloy. They are said to have the advantage of offering great resistance to strains of traction, and being very pliable and inoxidisable, and of resisting any attack of corrosive water (?); they also preserve their pliability after wear. These phosphor-bronze ropes are used in Belgium at the Bois-du-Luc, Horlez and Courcelles, Nord, Collieries. (February 1877.)

BRONZES, JAPANESE. M. E. J. MAUMENÉ brought before the Académie des Sciences, on April 19, 1875, the following as the results of his analytical examination of four different bronzes from Japan. (See Tables on next page.)

The importance attached in Japan to the manufacture of bronzes, which are used by that people not only for ornamental works of all kinds, but for culinary utensils and for machinery, renders this examination of much interest.

Composition	I.	II.	III.	IV.
Copper	86·38	80·91	88·70	92·07
Tin	1·94	7·55	2·58	1·04
Antimony	1·61	0·14	0·10	...
Lead	5·68	5·33	3·54	...
Zinc	3·36	3·08	2·71	2·65
Iron	0·67	1·43	1·97	3·64
Manganese	...	trace	...	...
Silica	0·10	0·16	0·09	0·04
Sulphur	...	0·31	...	...
Loss	0·26	0·79	0·21	0·36

M. Maumené considers these bronzes as the direct result of the use of copper pyrites and antimonial galena mixed with blende.

Professor Kalischer, of Berlin, has published his analyses of four Japanese bronzes. The following is the composition of each:—

Composition	I.	II.	III.	IV.
Copper	95·77	51·10	76·60	76·53
Lead	...	...	11·86	12·29
Silver	0·08	48·93	...	...
Gold	4·16	0·12	...	...
Zinc	...	...	6·53	6·66
Tin	...	...	4·38	4·30
Iron	...	...	0·47	0·03

The first, which contained much gold, had a light red colour, with a bluish black, lustrous patina on one side. The second, which contained silver, had a grey, almost silver white colour, with a slight shade of yellow. III. and IV. resembled brass in colour, and were, as the figures show, almost identical. Externally they were exactly alike, except that one had a fine crust outside which gave it a duller look than the metal itself. They differ from our bronzes in having so much lead in them, and the amount of zinc in the latter is generally much less.

In 1866 R. Pumpelly published the composition of a number of Japanese alloys, which showed the greatest conformity with the above. A native worker in metals allowed Pumpelly a glance into the preparation of the metals, which is generally kept secret, and he described, under the name of *shakdo*, alloys of copper and gold in which the quantity of gold varied from 1 to 10 per cent. They have a bluish black patina, which is produced by boiling the metal in a solution of sulphate of copper, alum, and verdigris. *Gineshibuichi* is the native name for an alloy of silver and copper, in which the amount of silver varies between 30 and 50 per cent. When boiled in the above-named solution, the alloy acquires a grey colour much admired by the Japanese. The name of *Karakane* is given to a sort of bell metal, consisting of copper, zinc, tin, and lead.

Bronzes and Brass.—Our trade during 1874 and 1875 in brasses and bronzes was as follows:—

Brass, Manufactures of, not being Ordnance.—Exports.

Countries	1874		1875	
	cwts.	Value	cwts.	Value
To Russia	4,377	£28,220	3,775	£26,498
,, Sweden and Norway	3,241	17,796	4,434	25,495
,, Denmark	1,821	10,490	1,606	10,019
,, Germany	28,710	229,118	7,606	43,463
,, Holland	13,597	78,155	17,935	91,278
,, Belgium	3,936	21,454	3,029	19,537
,, France	1,130	9,617	981	9,060
,, Portugal, Azores, and Madeira	1,903	10,479	1,552	7,831
,, Spain and Canaries	4,755	25,609	5,032	24,944
,, Italy	3,493	17,845	6,367	30,514

Countries	1874		1875	
	cwts.	Value	cwts.	Value
To Turkey Proper	4,747	£25,407	3,536	£18,928
„ Egypt	6,098	37,533	4,046	18,269
„ Western Africa (foreign) .	4,992	24,256	3,293	14,669
„ Foreign West Indies . .	847	4,260	...	...
„ China	...	...	1,765	10,573
„ Brazil	619	3,763	1,474	7,993
„ British Possessions in South Africa	1,916	9,567	1,289	7,253
„ British India, Bombay, and Scinde	2,107	12,099	2,103	11,506
„ Madras	137	847	376	1,971
„ Bengal and Burmah . .	2,208	14,567	3,150	17,770
„ Straits Settlements . .	1,691	7,816	2,523	11,820
„ Australia	3,704	22,786	5,955	35,510
„ British North America .	628	3,401	761	4,597
„ Other Countries . . .	6,011	37,013	6,948	37,087
Total	104,760	659,975	90,033	489,965

Brass, Bronze, and Metal Bronzed and Lacquered.—Imports

Countries	1874		1875	
	cwts.	Value	cwts.	Value
From Germany	1,172	£8,770	1,628	£11,261
„ Holland	553	4,048	765	6,053
„ France	2,975	46,672	8,352	50,078
„ Japan	1,310	4,957	...	...
„ United States of America .	4,666	39,932	3,837	37,296
„ Other Countries . . .	1,364	7,551	339	2,762
Total	12,040	111,932	9,841	107,450

BRYOÏDIN or **BREIDIN.** Resins separated by Baup and Flückiger from gum elemi. Bryoïdin melts at 135° C., and sublimes. The crystals are anhydrous; soluble in alcohol, chloroform, ether, acetic acid, glycerine, and essential oil of elemi. These crystals gave on analysis $C^{20}H^{38}O^3$.

BRUNSWICK BLACK or **JAPAN BLACK.** (Japan Lacquer, Japanning, vol. iii. p. 7; Lacquer, vol. iii. p. 82.) Considerable secrecy is observed respecting the manufacture of these lacquers or varnishes. The Japanese excel in the production of these varnished surfaces, and hence the name of 'japanning' has been adopted. Both mineral and vegetable asphalt are said to be employed in the manufacture, but the existence of the latter is open to doubt. Under the term 'bitumen' are included several distinct species, the most prominent being naphtha and asphaltum. For the above black varnish, however, some of the many varieties of asphaltum are employed. The solid black and brownish black asphaltum is preferred to any other by the manufacturer. The asphaltum of Dalmatia is selected for the best varnishes, and by some, especially French manufacturers, the bitumen of Judæa is much employed. The pitch of the pitch lake of Trinidad has also been much used for these black lacquers. Whatever variety is selected, it is broken into small pieces and dissolved in some essential oil, as turpentine, or, still better, in naphtha, and for the common kinds in some fixed oil. Whichever may be employed, considerable heat is necessary to effect perfect solution, and not unfrequently some pressure is used.

Some manufacturers mix the asphaltum with siliceous sand, powdered quartz, or powdered glass. This is to prevent the asphaltum from flowing into a mass at the bottom of the vessel.

When any of these insoluble substances are used, the mass admits of being stirred, and consequently the solution of the pitch is more rapidly effected. In a recent trial, Bessey v. Dickinson, it was sought to be proved 'that there was such a thing as vegetable gum asphaltum, and that such asphaltum was used in making the varnish'

(*Lord Justice James's Judgment, Court of Appeal*, November 20, 1876). It does not appear what variety of 'gum,' as it was called, was employed.

BUTTER. HAGER and KUNSTMANN state that a pure butter may be distinguished from adulterated butter by moulding the sample, in small pieces, around little cotton wicks, lighting the wicks, allowing them to burn fairly and fully, then to extinguish the flames and examine the odours evolved.—*Chem. Centr.* 1875.

BUTTEREINE, and BUTTER, ARTIFICIAL. Under the name of 'buttereine' a new preparation has been introduced in America, which has been attracting some attention. It is the invention of a Mr. BENN SMITH, of San Francisco, and from his own description we abstract the following:—

It is made by subjecting milk, in connection with a base of prepared butter, to 'chemical action and mechanical agitation, by means of which the curd is precipitated and the oily globules are burst and gathered together to form butter.' In preparing the butterine, it would seem to be essential to have the base of prepared butter. This is obtained in the following way. The inventor procures an earthenware cylinder with zinc cover, the upper lid being perforated to permit of the escape of steam. These zinc covers are coated with saltpetre, an operation which may be performed by heating a quantity of the salt in a kettle and exposing the cover to the steam jet from the spout. When thus prepared, a quantity of good sweet butter is placed in the cylinder, packing it loosely so as to have a space at the bottom, and the cylinder is then set in a pan containing an aqueous solution of salt at 98° Fahr., sufficient in quantity to make the depth about a quarter of an inch. The cylinder is now to be revolved, and upon one of its sides a jet of steam and on the other a blast of air are directed. This operation is to be continued until a 'certain oil,' which would interfere with the after processes, is extracted, five minutes being occupied in extracting the oil (about 1 oz.) from 1 lb. of butter, leaving the latter in the state required for the successful preparation of the butterine. To 1 lb. of this prepared butter the yolks of two eggs are to be added, when they have been well beaten and mixed with sufficient lukewarm water to enable them to be readily strained. The yolks are for the purpose of obtaining a settling action in the milk, and a consequent accumulation of butter in a mass when the churning is in progress.

The churn is taper in form and is of ordinary tin plates, but the bottom is a concave zinc plate with its concavity inwards, the lower edge of the body forming a perforated flange. The upper part is fitted with a rim, having a lip extending downwards, so as to fit into the upper part of the heater, thus forming a chamber, in which the steam and heat are retained. A suitable cover, and a dasher provided with spiral or inclined holes, complete the parts of the churn proper. The prepared 'base' of butter is placed in this churn, principally at the bottom, but the sides may also be coated by rubbing it over them with the hand. Previously, however, to placing the 'base' in the churn, the heater should be prepared. It is merely a cylindrical vessel of zinc, coated with saltpetre in a manner similar to that described in connection with the zinc covers in the preliminary operations. A tablespoonful of saltpetre is then dissolved in two gallons of water and boiled down to one, which is then poured into the heater, a teaspoonful of salt added, and the whole well stirred. When the temperature has fallen to 110° Fahr., the milk (one gallon to the quantities above named) is to be poured into the churn, which already contains the prepared butter and egg yolk, and the churn placed in the heater containing the warm solution of saltpetre. The dasher is then to be worked in the usual manner for about a minute, more or less, according to the quality of the milk, when the churn may be removed and placed in the cooler. This cooler is made of zinc, and its interior is coated with saltpetre as before described, and it should contain about a gallon of cold water in which a tablespoonful of salt has been dissolved. The dasher is again operated for about half a minute, when it will be found that the milk has entirely disappeared and a compound has been produced resembling fresh butter in appearance and taste. The compound thus formed from the milk consists mainly of curd or cheese and butter, and when once made, a portion of it may be used in producing a further quantity of buttereine.

Several processes for the manufacture of *artificial butter* have been recently introduced. Mr. BREWER patents on behalf of M. E. DUBOURDIEU a method of making artificial butter, which is thus described:—

The tallow or other fatty matter is first washed in cold water, cut into pieces, and placed in a wooden vessel, and melted by means of steam heat. A solution of soda of 1 per cent. by weight is then added, and the fat well boiled, similar quantities of soda solution being subsequently added, and the whole boiled two or three times if necessary. The mixture is then to be boiled again in pure water and strained through flannel. When the temperature has fallen below 144° Fahr. it is placed in the churn, and during the churning 2 per cent. of fine oil and from 3 to 4 per cent. of buttermilk or sour milk is to be added. In about a quarter of an hour the so-called butter will

appear, which is to be removed and kneaded in cold water, and otherwise treated as ordinary butter.

Mr. Hipkins, of Tipton, has also patented a method of making an artificial butter 'possessing the smoothness on the palate peculiar to real butter,' and in a great measure also its flavour. Beef, mutton, or pork fat, or mixtures of them, is melted by steam heat in suitable vessels, and after allowing time for settling is drawn off to cool. At a raised temperature it is submitted to hydraulic or other pressure in order to separate the oleine from the stearine. This oleine is subsequently melted and suddenly reduced from a comparatively high to a low temperature, with violent agitation in water and salt, to which a little soda has been added.

In defence of this process, it has been somewhat ingeniously said: 'Knowing, as we do, the composition of the various fatty bodies entering into the composition of butter, and having it in our power to prepare these in a pure state at a comparatively low price, we might certainly turn our attention to the production of a compound which, although it might not be gifted with exactly the same physical aspect as the real article, yet which should possess the same essential properties of taste, smell, and general nutritive effects, at a price such as would place an abundant supply within the reach of all. The palmitates, the oleates, and the stearates of glycerine can now be obtained cheaply in a state of purity; the flavouring principles such as the glyceric compounds of butyric, caproic, and similar acids can also be cheaply prepared from the products of the distillation of coal tar and similar substances. Surely there is room for experiments in this direction—and if he who can induce two blades of grass to grow where formerly only one appeared, is a benefactor to mankind, he who will liberate milk from the drain entailed upon it by the production of butter, and who will yet produce a good butter of uniform quality and comparatively low price, will be none the less so.'

The subject certainly merits attention; complete and exact analyses, leading to a determination of the amounts and nature of the inorganic bodies which exist in small proportions in good butter, and which probably influence its assimilability, are requisite; for it would certainly appear that the presence of even infinitesimally small quantities of fluorides, phosphates, and other salts, influence the effects of food on the system, as these small doses being repeated for a lifetime must have an effect eventually.

A large stearine candle manufactory in Marseilles is, it is said, turning out many tons weight of a substance known as *graisse alimentaire* and *beurre factice*. This margarine is also manufactured in Glasgow, and it is said to be sold mixed with butter as the pure produce of the dairy.

Of Butter our *Exports* have been—

	1874		1875	
	cwt.	£	cwt.	£
To Portugal	21,396	132,552	22,014	137,121
„ Brazil	8,476	52,065	6,890	34,946
„ Gibraltar	2,754	16,408	3,237	19,025
„ Malta	1,043	6,439	1,268	7,170
„ British Possessions in South Africa	1,523	8,673	1,507	7,740
„ British West India Islands and British Guiana	4,107	22,924	2,316	15,709
„ other Countries	3,290	20,280	3,494	20,501
Total	42,688	250,331	39,266	240,281

While our *Imports* for the same period were as follows:—

	1874		1875	
	cwt.	£	cwt.	£
From Sweden	23,292	138,070	27,939	160,711
„ Denmark	220,053	1,363,435	206,171	1,275,870
„ Germany	135,027	767,191	108,878	645,906
„ Holland	351,605	1,877,755	357,106	1,917,910
„ Belgium	76,723	465,517	79,960	499,028
„ France	716,251	3,944,235	587,560	3,367,219
„ United States of America	38,307	185,769	40,331	205,940
„ British North America	60,282	269,362	78,055	370,221
„ Channel Islands	—	—	4,262	24,644
„ other Countries	7,258	35,005	1,067	5,675
Total	1,619,808	9,050,025	1,467,870	8,602,084

BUTYLENE. (C^4H^8). One of the hydrocarbons, the knowledge of which is incomplete. See WATTS's *Dictionary of Chemistry.*

C

CADMIUM. (Vol. i. p. 570.) *Blowpipe Reaction.*—When cadmiferous zinc ores, or furnace products derived from them, are treated in powder, with carbonate of soda on charcoal, the characteristic red-brown deposit of cadmium oxide is formed at the commencement of the experiment. Professor CHAPMAN, in his paper on this subject (*Philosophical Magazine*, December 1870), gives some minute directions for avoiding any error arising from the presence of arsenic or antimony.

CÆSIUM. (Vol. i. p. 570.) It is stated that cæsium was detected in the hot spring of Clifford Amalgamated Mines, in Gwennap, Cornwall. The water was said to contain 1·71 part of chloride of cæsium to a million parts by weight—or 0·12 in a gallon—which is about ten times the quantity found in the Dürkheim water.—Colonel YORK, *Chemical Society's Journal* (2), x. p. 275. However this may have been, we are now entirely cut off from this supply. At 235 fathoms from the surface, in that part of the above mines which was formerly known as the United Mines, a vast outflow of water occurred, the temperature of which varied from 120° to 126° F. This was analysed by Dr. ALLAN MILLER, and found to contain large quantities of lithia, and in association with this Colonel YORK found the chloride of cæsium. These mines have been abandoned for some years, and are now filled with water to the adit. Mr. JOHN ARTHUR PHILLIPS found lithium in a hot spring issuing from the bottom of Huel Seton copper mine, near Camborne, in Cornwall. It is not improbable but that cæsium may be found in that water. SONSTADT detected cæsium and rubidium in sea water and in sea weed.

Cæsium is obtained principally from lepidolite. For the chemical processes used by STOLBA and by LECOQ DE BOISBAUDRAN, see *Dictionary of Chemistry*, by HENRY WATTS.

CALAVERITE. A mineral, accompanied by quartz and sylvanite, found at Red Cloud Mine, in Colorado. A specimen analysed by F. A. GENTH gave—

Au	Ag	Te	Cu and Fe		
40·59	2·24	57·07	trace	=	100·50
39·70	2·54	57·68	"	=	100·00

CALCAREOUS ALABASTER, *from Mexico.* This material is known in commerce as the Onyx of Secali. It varies in colour from milk white, yellowish white, to pale green, certain samples displaying brown veins shading into red. It takes a fine polish. Its specific gravity is 2·77. It is readily and entirely soluble in nitric acid. Its composition is—

Carbonic acid	43·52
Lime	50·10
Magnesia	1·40
Ferrous oxide	4·10
Manganous oxide	0·22
Water	0·60
Silica	traces
	99·94

M. A. DAMOUR, *Chemical News*, June 2, 1876.

CALCINER *for roasting Tin, Copper, and other Ores.* This calciner, the invention of Dr. ROBERT OXLAND and Mr. JOHN HOCKING, jun., is being largely used in Cornwall and Devonshire, and especially for those pyritic minerals which contain arsenic.

This calcining furnace consists of an iron tube, about 3 ft. 6 in. to 6 ft. diameter and 30 ft. long, lined with fire brick. It is set horizontally at an inclination of from a ½ to 1 inch per foot, varying according to the nature of the ores to be operated on. On the outside, and fastened to it, are three iron rings, on two of which the tube travels over two pairs of rollers, by which it is supported. On the third ring are cogs, by which rotary motion is imparted from suitable machinery. The fire passes

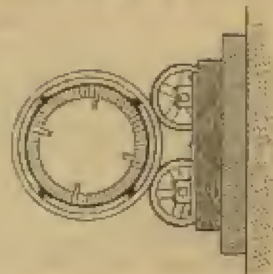
from the fireplace, over a chamber, into and through the tube, and on into flues covered for a short distance with iron plates, on which the damp ore is dried, before it is admitted in a regular steady stream, through a feed-pipe into the back end of the tube.

The slow motion of the tube, about one revolution in four minutes, causes the steady advance of the ore by its own gravitation.

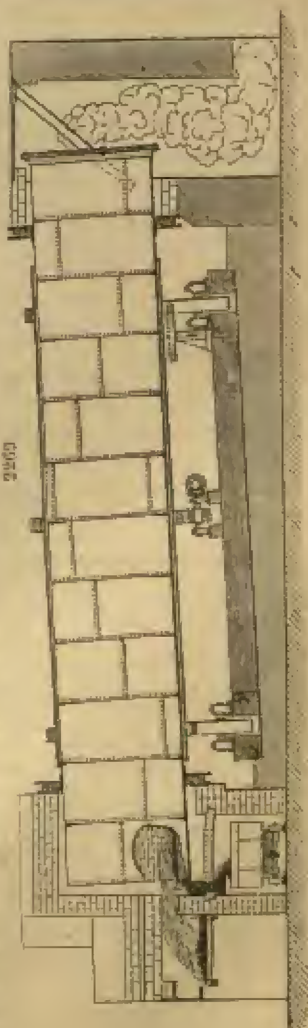
As it undergoes combustion, sulphureous and arsenious acids are evolved, so that the ore is not brought into the stronger heat until those constituents which cause the tendency to crust have been driven off, and it is consequently preserved in a fit condition for the completion of the oxidation of its metallic constituents, as it is advanced nearer the fire. In the interior of the tube are projecting ledges, which lift the ore for some distance above the sole of the furnace, and then project it through the passing stream of heated gases. This constant perpendicular revolving motion is of the greatest importance, as every particle of the ore is kept incessantly in motion, and is thereby brought into contact with the oxygen of the heated gases passing through the furnace. The calcined ore is discharged in a continuous stream into the chamber between the fireplace and the front end of the tube.

The whole arrangement may be understood by reference to the annexed drawings of a transverse section of the tube (*fig.* 2270), and a longitudinal section of the whole apparatus (*fig.* 2269).

2270



2269



Great economy of fuel is effected by this furnace, inasmuch as the heat evolved by the combustion of the sulphur and arsenic is rendered available to such an extent, that fuel is required only for the completion of the operation; and if the ore contain 12 per cent. of arsenic, and about the same quantity of sulphur, no coal is required after the furnace is brought up to full heat.

The product obtained contains only traces of arsenic, with 1 or 2 per cent. of sulphur; or, if desired, the calcination may be so managed as to drive off all the arsenic, but leave nearly all the sulphur in the ore.

When arsenical ores are treated in the furnace, the evolution of the arsenious acid at a minimum temperature—as effected by avoiding the use of fuel—is a matter of great importance, as the rapidity and effectiveness of condensation of white arsenic is obtained with a much less expensive system of condensing flues than such as is usually employed.

The labour required is limited entirely to the maintenance of the fire, the supply of the raw material, and the removal of the calcined product. One man and two boys can work two of the calciners of the largest size.

The great advantages of this furnace consist—in its simplicity of construction, and consequent low prime cost; in its durability and small expense for maintenance; in its efficiency and rapidity of action; in its economy of fuel and labour; and in its non-liability to derangement, as none of the working parts are exposed to the action of the fire.

At Devon Great Consols, three of these furnaces are at work, one of 6 ft., and the other two 3' 9" outside diameter. The larger one turns out 25 tons of ore per diem, each of the other two 15 tons, making together about 55 tons per diem. The ore operated on contains 12 to 15 per cent. arsenic, and about the same quantity of sulphur. It is crushed to pass through a 4-hole sieve, i.e. ¼ inch square. The product contains less than 0·5 per cent. arsenic and less than 2 per cent. of sulphur; but when so wanted it may be obtained practically free from arsenic, but still containing 10 to 12 per cent. sulphur. It is intended to use it, instead of kilns, in the manufacture of sulphuric acid from Spanish pyrites. When properly attended, so as to keep up a regular feed, it has been kept to work for weeks together without the use of any coal as fuel. Its action is very superior to that of kilns, inasmuch as practically the whole of the arsenic is evolved, whilst in kilns seldom less than 2½ to 3 per cent. of arsenic is left in the ore, principally in the form of arseniate of iron.

CALCINING FURNACE. See FURNACE, CALCINING.

CALCIUM, CHLORIDE OF. (Vol. i. p. 573.) Mr. JOHN SPILLER has drawn attention to the existence of native chloride of calcium at Guy's Cliff, Warwick Castle. The rock, a friable micaceous sandstone of a greyish white colour, gave—

	grams
Sand and mica (insoluble in acids)	23·91
Alumina and oxide of iron, with a little silica	0·31
Carbonate of lime	0·50
Pyrophosphate of magnesium	0·22

The saline deposit—a black slime on the face of the rock at Guy's Cave and the Monks' Cell, gave—

	grams
Chloride of potassium	1·21
,, sodium	11·03
,, magnesium	3·81
,, calcium	27·15
Sulphate of calcium	14·55
Nitrate of calcium	trace
Water and vegetable extractive	42·25
	100·00

Journal of the Chemical Society, February 1876.

CALICO. *Exports* of printed, dyed, or coloured goods:—

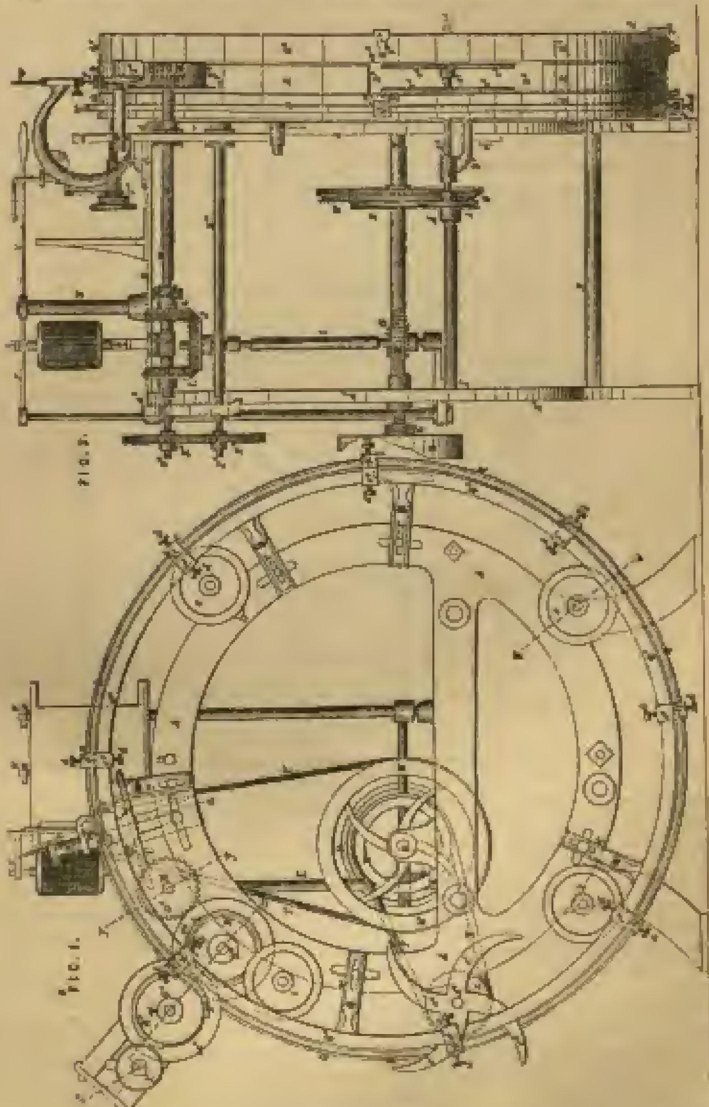
	yards	Value £
1874	1,003,101,107	19,002,706
1875	1,001,025,569	19,000,918
1876	988,287,700	18,487,193

CALICO PRINTING. *Fixing of Alkaline Red Mordant.*—The colours 31 and 32 on page 622 (CALICO PRINTING), vol. i., require a peculiar method of fixing, which was accidentally omitted when describing the 'dunging process' for fixing the ordinary madder mordants. The method is as follows:—After 'ageing' the goods are passed through a cistern placed in front of the ordinary fly-dunging apparatus; this cistern is provided with rollers at top and bottom, and is set with a solution of sal ammoniac at 4° T. or about 1 lb. per gallon; the heat is 160° Fahr., and the time a piece of 25 yards occupies in passing through is 40 seconds. The apparatus described in *figs.* 373 and 374 answers very well for this purpose, as the first division A, *fig.* 373, is suitable for setting with salammoniac liquor. The goods pass direct from this into the fly-dung cistern, set with cow-dung only, temperature 160° Fahr., are then washed, second dunged, and then follow the usual routine for madder goods. In this process the soda which had been partially neutralised by the carbonic acid of the air is completely so by the sal ammoniac, chloride of sodium and ammonia being formed, and alumina precipitated on the cloth. This mode of mordanting for red is only practised for the style Swiss pinks, (page 635), some printers preferring to mordant with alkaline red, under the idea that the mordant cannot possibly contain iron.

Sewing Machine.—An American machine has within the last year or two been introduced to calico printers, which appears to have peculiar merits, for there is scarcely a print works now without several of them. It is the BATES and LANCOLN machine patented in 1872. The following drawings and description are taken from the printed specification.

Fig. 2271 is a front view, and *fig.* 2272 a side view of a machine constructed according to these improvements; *fig.* 2273 is a plan of the same.

Fig. 2271, A, A², represent the framework of the machine, consisting principally of two parallel upright frames, secured together and braced by horizontal cross rods B at suitable points; C is the driving shaft, arranged horizontally and transversely to framework A, A², and turning in suitable bearings thereof; D is a loose pulley on driving shaft C, and E a sliding clutch on shaft C for connecting the pulley D with, or disconnecting it from, the driving shaft C. The clutch E is operated by the lever handle F.



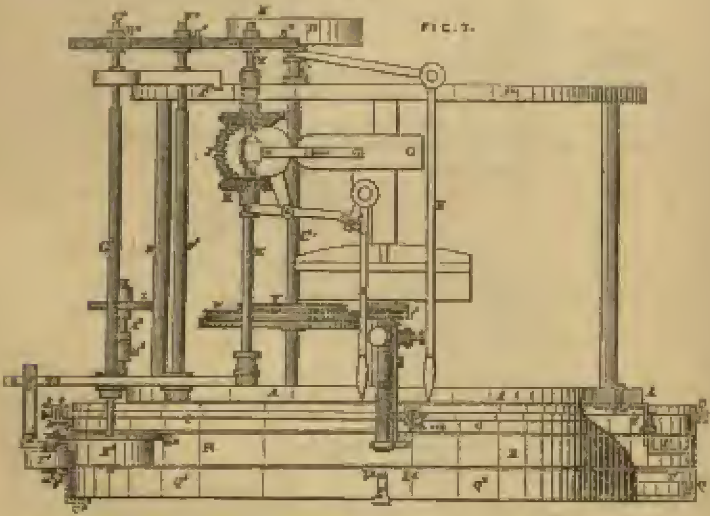
2271
2272
FIG. 1.
FIG. 2.

G is a worm gear wheel on driving shaft C, and H a horizontal gear wheel engaging with worm G of driving shaft C; this gear wheel H is at the lower end of a vertical shaft I that is arranged at each end to turn in suitable bearings of the framework A, A², and at its upper end is provided with a horizontal bevel gear wheel J engaging with two similar vertical gear wheels K and L of a common horizontal shaft M. The shaft M is at the upper part of the framework A, A², and extends from one frame to the

other, turning in suitable bearings of each. The bevel gear wheel K is adapted to be slid into and out of connection with the gear wheel J by the lever handle N, which is connected therewith as shown.

O, O², are two similar vertical gear wheels at the front end of horizontal shafts M and outside of front frame A. Each gear wheel O, O², is in position on horizontal shaft M to engage with the interior toothed periphery P of similar rings or annular frames or bands Q, Q²; the gear wheel O with the annular frame Q and the gear wheel O² with the annular frame Q². These frames Q, Q², are arranged in vertical positions outside of the upright frame A with the annular frame Q² in front of the annular frame Q, leaving a space between them closed by an annular frame or ring R. The peripheries of the several annular frames Q, Q², and R, horizontally correspond with each other. The annular frames Q, Q², are free to turn and are both supported upon similar vertical friction rollers or wheels S arranged upon the front frame A so as to bear and run upon the inner periphery of the annular frames Q, Q². The annular frame R is fixed in position through stay arms T at suitable points that are secured to the front frame A, see *fig.* 2271. The frictional rollers or wheels S and the stay arms T in their attachment to the front frame A are adapted for adjustment by slots

2273



and set screws or bolts and nuts, as fully shown in the drawings, and needing no more particular description herein. The annular frames Q, Q², are each provided along their respective peripheries with radial projecting points a, b, and a^2, b^2. The points a and a^2 of the two frames Q, Q², are fixed in position while the points b, b^2, are attached to slides or clasps c, c, respectively, that in their application to the annular frames Q, Q², are adapted, as shown in the drawings, to be slid or moved around the frames Q, Q², to any position desired and there firmly set by properly screwing the thumb or milled head set screws d of the slides.

T² is the sewing machine proper, which in the present instance is what is known as a 'WILLCOX's and GIBBS'' sewing machine. This sewing machine in its construction and arrangement of parts is in every respect similar to the ordinary sewing machines of the class stated, and therefore needs no particular description, the only difference being in the fact that the feed mechanism of the machine is dispensed with. The sewing machine T² is located at the upper part of the framework A, A², and is there firmly secured to a table or platform U of the framework A, A², and in its location the needle f is in a position to pass downward and upward through a hole g in the fixed annular frame R, between its two edges, and to produce the stitch as ordinarily by the action of the looping mechanism h of the sewing machine, which looping mechanism is under or within the annular frame R.

U² is the driving pulley of the sewing machine; this pulley U² through an endless vertical belt V is connected to the pulley W of the driving shaft C, and thus receives its motion; X is a pulley on driving shaft C, connecting such shaft through the endless

belt Y with a pulley Z of a horizontal shaft A^2 at one side of the front frame A. The horizontal shaft A^2 turns in suitable bearings of the stirrup shaped arm B^2 of front frame A, and it is extended forward through the annular frames Q, Q^2, and H, to the front of the machine. Within the frames Q, Q^2, and H, the shaft A^2 is armed with radial curvilinear spokes or arms C^2, so projecting that as the shaft A^2 revolves they will extend through the opening D^2 of the fixed annular frame H, as shown, and beyond the outside of such frame H. Between the point of location of the sewing machine T^2 and the spoked or armed shaft A^2 and within the plane of the fixed annular frame H, are arranged two wheels E^2, E^3, the one E^2 within the annular frame H, and the other E^3 without the same, with their centres in a corresponding radial line of the frame H. The inner wheel E^2 is at one end of a horizontal shaft F^2, and the outer wheel E^3 is at one end of a horizontal shaft G^2, and both of these shafts F^2 and G^2 are arranged to turn in suitable bearings of the framework A, A, extending from one frame to the other, and adapted to be driven with a uniform motion by means of the gear wheels H^2 connecting the one with the other and the shaft F^2 with the horizontal shaft M, hereinbefore referred to. The wheel E^2 is adapted for the reception of type as shown, and for inking the same to adapt them to give an impression there is arranged an ink supplying roller I^2 to bear thereon as shown, this ink roller obtains its supply from a casing or receptacle applied thereto. The wheel E^3 has an elastic cushion of india-rubber or other suitable material l surrounding its periphery, and for the one wheel E^2 to bear upon the other wheel E^3 the fixed annular frame H is suitably cut out. Both these wheels E^2, E^3, at their inner ends are provided with projecting flanges m, m^2, respectively, which flanges in the location of the wheels pass by each other, acting as the wheels turn like a pair of shears to cut or trim along such line any material passed between the rollers or wheels E^2, E^3.

Under the above described arrangement and construction of parts with power applied to the driving shaft C, the annular frames Q, Q^2, are made to turn, both moving similarly and equally; the sewing machine T^2 is driven; the type wheel E^2 and its cushion wheel E^3 and the spoked or armed shaft A^2 are revolved; the annular frames Q, Q^2, are for the reception of the goods as will be hereinafter described, and they turn from the sewing machine toward the type roller E^2 and its mate roller E^3, which rollers revolve in the proper direction for the goods carried by the annular frames Q, Q^2, to pass between them; the spoked or armed shaft A^2 revolves in a similar direction to the annular frames Q, Q^2.

In the use of a machine such as above described, two pieces of goods to be sewed together end to end are first laid flatwise one upon the other, so that their two ends correspond and then are fastened to the frames Q, Q^2, first upon the two nearest fixed pins or points a, a^2, of the frames Q, Q^2, of the sewing machine T^2, and thence are stretched transversely over the periphery of the combined annular frames Q, Q^2, and H, and by the adjustable pins or points b, b^2, properly adjusted therefor are secured.

With the goods thus secured on the annular frames Q, Q^2, extending across the annular frame H, the machine is set in motion, when by the movement of the annular frames the goods are carried gradually along to the sewing machine, by which in a line between the inner and outer points of their fastenings to the annular frames Q, Q^2, they are sewed or stitched together, and thence they pass to and between the type and cushioned rollers E, E^3, by which they are not only stamped or marked, but are cut or trimmed outside of the line of stitches by the action of the cutting or shear flanges m, m^2, of the rollers E^2, E^3. From the rollers E^2, E^3, by the continued movement of the annular frames Q, Q^2, the goods are carried forward to the spokes or arms of the shaft A^2, which acting thereon as the shaft revolves, force off the goods from the points a, a^2, b, b^2, of the annular frames Q, Q^2, discharging them from the machine. While two pieces of goods are thus being acted upon in the machine, the annular frames Q, Q^2, as they turn are being prepared similarly with another set of pieces, so that when the sewing machine has finished sewing the first set it will pass directly on to the next set, and so on, the annular frames Q, Q^2, being suitably provided with points or pins a, a^2, b, b^2, therefor.

By suitably adjusting the slide points on the annular frame Q, Q^2, it is obvious that goods of varying widths may be sewed in the machine.

In lieu of two annular frames Q, Q^2, in connection with the stationary frame H, only the frame Q need be employed, but it is preferable to have two, one inside and one outside of the line or plane of stitching, and to hold the goods both inside and outside of the line of sewing, as thereby a most perfect and even stretch of the goods is not only obtained but maintained.

By marking the goods as described with any particular characteristics it is obvious where machines such as herein described are used for the sewing of goods of different mills all confusion as to which mill the goods belong will be obviated, and by the

described trimming of the ends perfect and even seams and ends are produced, thus rendering the operation of printing more perfect and uniform.

Aniline Colours printed along with Mordants for dyeing with Madder or similar dye-stuffs.—A style of a similar nature to that patented by LIGHTFOOT (vol. i. p. 630) was patented in America in 1876 by JAMES HADLEY, and in England by JAMES CHADWICK, as a communication from HADLEY. By this process very clear and beautiful aniline colours, particularly green and purple, are printed along with the ordinary iron and alumina mordants, and undergo the usual process for dyeing and clearing such mordants, the finished result being a pattern containing red, black, brown, chocolate, green, and purple colours, thereby to a great extent obtaining the beauty of the chintz style blocked after dyeing with a great superiority in register. The following description is taken from the printed specification:—

'These improvements consist in simultaneously fixing or applying to textile fabrics, especially those made of cotton, the greens, violets, and purples known as iodine or methyl greens and aniline violets, together with the mordant or mordants destined to be dyed up in natural or artificial colouring matters of madder, garancine, or alizarine, alone or in combination with other colouring matters, such as red woods, Quercitron bark, Persian berries, or sumac, whereby styles can be produced not heretofore obtainable.

'The invention is carried out as follows:—I take two hundred pounds of sumac, to which is added one hundred and fifty gallons of water, and boil the mixture an hour or so, and then put upon a filter. After being filtered, the sumac liquor is boiled down to stand at 24° Twaddell's hydrometer. For my green colour I take at the rate of ten gallons of sumac liquor standing at 24° Twaddell, two gallons acetic acid at 10° Twaddell, and twelve pounds of starch. Then the whole is boiled, and when it is cooled to about 180° Fahr. I add at the rate of ten ounces tartaric acid to the gallon, and when cooled down to about 120° Fahr. I add at the rate of two ounces of oxalic acid to the gallon, and when quite cold I add at the rate of three ounces of aniline green chemically pure to the gallon. The colour is then ready for printing on the cloth.

'To make my purple I take seven gallons sumac liquor standing at 20° Twaddell, and three gallons acetic acid at 10° Twaddell, and ten pounds of starch. Boil the whole, and when cooled to 140° Fahr. I add at the rate of eight ounces of tartaric acid and four ounces aniline purple to the gallon. This colour is now ready for printing on the cloth.

'I take cloth known to printers as cloth that has received a madder bleach, and pass it through a solution of chlorate of potash standing at 2° Twaddell, dry it, and then it is ready for printing. Pass it on to the printing machine, where the mordants intended for dyeing, and the aniline green or the green and purple are printed at once, that is, at the same time.

'The cloth is passed through a box known as an 'ageing box' and afterwards passed through silicate, arseniate, or phosphate of soda at 2° Twaddell, and standing at 180° Fahr. or thereabouts. The pieces are then washed and dyed.

'I do not limit myself to these proportions, as they will have to be varied to suit the pattern.

'After having been passed through the silicate the green and purple are sufficiently fixed to pass through the dyeing and soaping operations.

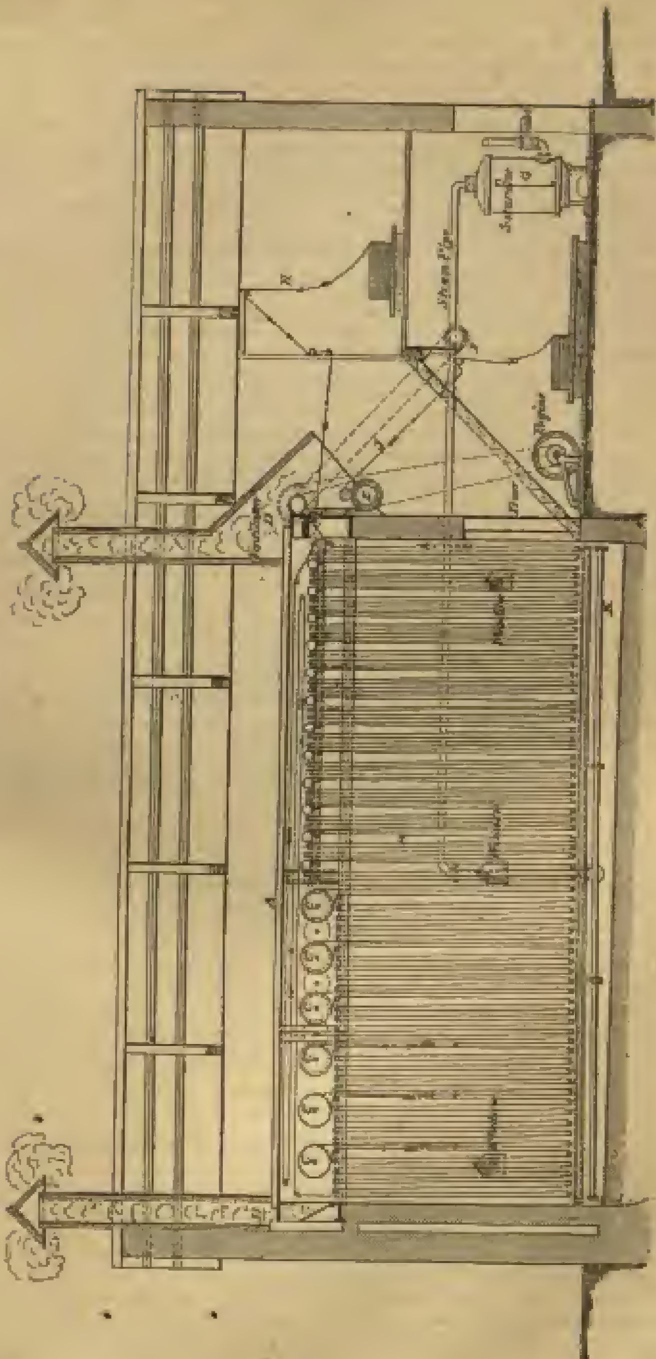
'I have named in the above formula what is known as pure aniline purple, but the same process is applicable to any of the aniline purples and violets, taking the corresponding strength of each.

'Another mode of effecting the same purpose, though not so simple as the one just described, is as follows:—In the first place I pass my cloth through the following solution previous to printing: Gelatine standing at 2° Twaddell's hydrometer, silicate of soda at 1½° Twaddell, chlorate of potash standing at 2° Twaddell. The cloth is then dried, and is ready for the printing machine. I may here state that the three solutions above are mixed together, and the cloth passed through them at once.

'To make my green colour I take four and a half (4½) gallons extract of sumac standing at 20° Twaddell, six pounds of starch; boil ten minutes, and when half cold I add two and a half pounds tartaric acid, one pound oxalic acid, and one and a half pounds methyl or iodine green. This is printed on the cloth already passed through the above solution in combination with regular mordants. By this means I get an insoluble tannate of gelatine.

'I have named in describing my invention methyl and iodine greens, as these are the most common used of the aniline greens; but any other of the varieties of the aniline greens may be substituted, reference being had to the strength of the commercial articles substituted.

2275



'After the goods are dried and aged one night, I pass them through a solution of silicate of soda at 2° Twaddell, and heated to 180° Fahr. or thereabouts, and afterwards through arseniate of soda. The goods are then well washed and dyed to suit the pattern with different proportions of alizarine, garanceine, artificial alizarine, madder, sumac, bark, berries, and such other materials as are ordinarily employed in this style of work, as is well understood by competent dyers.'

Apparently in this process it is the tannic acid of the sumac which forms a precipitate with the aniline dye, which, temporarily held in solution by the acids employed, is precipitated on the cloth partly by evaporation of the acetic acid and partly by neutralisation of the other organic acids by the silicate, arseniate, or phosphate of soda used in dunging. This tannate is not permanently stained by the garanceine, madder, alizarine, or other dyestuff.

Continuous Steaming.—In 1875 Mr. THOM of Birkacre fitted up an apparatus for steaming printed goods in a continuous manner, by passing them through a brick chamber fitted with rollers top and bottom, with steam blown freely in at the bottom; the apertures for the admission and exit of the pieces were only just wide enough and deep enough to allow the pieces to pass through without scraping; an aperture was provided at the top which could be regulated by a valve for the exit of steam carrying with it acid vapours. Several minor details were provided, unnecessary to mention here, and at length the machine was made successful for several styles, and Mr. THOM patented the invention. Soon after Messrs. CRUM of Thornliebank and a Russian house began to make experiments, and one or more patents were taken out for the same object. Messrs. MATHER and PLATT sought to combine all possible improvements in a patent dated January 21, 1876. The drawing, *fig.* 2275, is kindly supplied by this firm, and also the following description:—

A is the double cased wrought-iron roof of the steaming chamber, filled with steam (say of 5 lb. pressure) to prevent condensation, and consequently, drops from forming and falling on the cloth in its passage through. The inlet and outlet are also provided with a steam chest for the same purpose.

B.—The steaming chamber, which is built of brick, is heated to the required temperature by steam turned in at a pressure of ½ of a pound, simply to produce moisture. When the required temperature has been obtained, the attendant will observe through the windows that the space inside the chamber is quite clear. This takes place at 212°.

Passing through the opening at front end of the chamber (which also serves as an escape for steam impregnated with the gases discharged from the printed cloth) the pieces travel continuously up and down alternately over a series of small rollers, and then over a heated cylinder, C. This is repeated until all the cylinders have been passed over: the cloth is then drawn along by means of rollers driven by gearing and delivered to drawing rollers, E, outside of the chamber, from whence it passes to the plaiter, F, and is plaited down.

It is necessary that all the gases generated from the printed fabric should be carried off as quickly as possible; for this reason, at the back end is placed a swivel door, which the attendant regulates according to the pieces passing through the chamber. These gases are then carried away by means of ventilating shafts, D D.

Highly saturated steam is required in this process, therefore a wrought-iron vessel, G, is placed in some convenient part of the room. This vessel is half filled with water, steam is forced into the water at a low pressure, and the vapour evolved in the boiling passes on through suitable pipes into the chamber to give the requisite moisture.

The whole time necessary to expose the heaviest colours, artificial reds, pigments, &c., is from ten to twenty minutes. The process is continuous throughout, the length of time needed for exposure in the chamber being regulated by the rollers revolving quicker or slower. No 'greys' are required for any class of work, and every kind of work can be equally well steamed by this apparatus. One man and a boy are sufficient to tend the working. About one third the amount of steam used in the ordinary way is sufficient for this new method.

One chamber 26 ft. long will steam from 1,500 to 2,000 pieces per day, according to the class of work.

It is difficult to say at present how far continuous steaming may replace the method described on pages 663 and 664, vol. i.; but the system is of great promise, and some large houses have commenced erecting the machine.

Alizarine, Artificial.—At the date of publication of the *Dictionary* this dyestuff, though discovered in 1868, by GRAEBE and LIEBERMANN, was still struggling with madder, and most printers were undecided what place to assign to it in their list of colouring matters, whether it was destined to replace madder, or to remain as a product, dyeing similar but not identical shades, and so only partly to replace it. At the present date so rapid has been the spread of the use of artificial alizarine, and so

persistently has the price of it declined, owing to its very large production, that madder of good quality can now be bought for 15*s.* per cwt., which formerly varied in price from 65*s.* to 45*s.* This low price does not repay the farmer anything like his outlay, and, as a matter of course, madder has ceased to be planted and will soon be a thing of the past, and exist as a manufactured product only in museums and calico-printers' laboratories. Nay, so closely and convenient is this new dyestuff in its application, that even at an equal price for an equal quantity of colouring matter, madder would not be bought. Many styles not capable of being done with madder have been introduced, especially imitations of Turkey red with aniline black freely introduced, where the shade of red so closely resembles Turkey red, and is so much more quickly and cheaply produced, that it is questionable whether even this celebrated dye will not before very long have become a thing of the past. Many varieties of artificial alizarine are now made, varying from almost pure alizarine to those dyeing very yellow shades of red. Anthrapurpurin, which dyes a splendid pure red and good purple, is sold as artificial alizarine, though having a somewhat different composition. Purpurine has been made by the process of LALANDE, by oxidation of alizarine to a definite stage by means of arsenic acid, and it appears now possible to imitate the madder colouring matters exactly, which was not the case so long as artificial purpurine remained undiscovered. Towards the end of 1875 M. STROBEL, of Mulhouse, discovered that nitrous acid gas acted upon dyed alizarine reds so as to turn them orange, which was not affected by soap. M. ROSENSTIEHL, of the same town, soon after took up the subject, and proved that the orange dyeing colouring matter is a mononitrated alizarine of composition $C^{14}H^{7}(NO^{2})O^{4}$. This variety of alizarine is now made on the large scale by some of the alizarine makers. It is used principally for dyeing aluminous mordants, oranges, which are perfectly fast to soap. Orange colour for printing topically is also made and fixed by steaming. Owing, however, to the very strong acid powers of the nitro-alizarine, the acetate of alumina or other aluminous mordant is soon decomposed by the nitro-alizarine, and an insoluble orange compound formed in the colour which does not attach itself to the calico, and meagre shades are produced. This property rather hinders the free use of this colour in topical printing. The following formulæ represent the way of using alizarine orange as a topical colour:—

No. 247. *Alizarine Orange.*—4 quarts of No. 248; 1 quart of alizarine orange at 10 per cent. dry colouring matter; 1½ gill of No. 249; ½ gill of No. 250.

No. 248. *Acid Paste.*—12 lb. wheat starch; 6½ gallons of water; ½ gallon of acetic acid; 5 gills of oil; boil and add 5 gills of spirit of turpentine; use cold.

No. 249. *Nitrate of Alumina.*—3 lb. lump alum; 3 lb. nitrate of lead; 3 quarts of hot water; dissolve and add ½ lb. of carbonate of soda crystals dissolved in 1 quart of hot water; stir well and let settle.

No. 250. *Acetate of Lime.*—Acetic acid at 8° T. neutralised with slaked lime and set at 20° T.

Another alizarine orange is as follows:—

No. 251. 1 quart of alizarine orange; 1 pint of acetic acid at 12° T.; 2 quarts of No. 252; 1½ gill of olive oil; mix well together; and when wanted for printing add 1½ gill of nitrate of alumina at 26° T.

No. 252. 5 gallons of cold water; 30 lb. of wheat starch, beat up fine and add the following—15 gallons of water; 5 lb. of gum tragacanth; boil till dissolved, and when cold make up to 15 gallons. Mix well with the beaten up starch, boil and cool.

Alizarine orange goods should be passed through vapour of ammonia previously to steaming, as the nitric acid disengaged by steaming would otherwise tender the cloth (vol. I. p. 664).

Methyl Green is now frequently printed along with alizarine red and aniline black in topical printing. For steaming the following is a good receipt for this colour:

No. 253. 2 quarts acetic acid at 12° T.; ½ quart of red liquor at 8° T. (p. 620); 1 quart Berry liquor at 2° T. (p. 617); 1½ lb. of starch; boil, and add 6 oz. of tartaric acid; 10 oz. of tannic acid; cool and add 3½ oz. of methyl green crystals (yellow shade) dissolved in 3 gills of acetic acid at 12° T.

Aniline Black.—In 1871 JOHN LIGHTFOOT, the inventor of aniline black, made a series of experiments with a great number of metals introduced into mixtures of hydrochlorate of aniline and chlorate of soda thickened as for printing, with a view to see which of them produced the same result as copper in causing the development of aniline black. The metals experimented with were copper, iron, vanadium, uranium, nickel, lead, zinc, antimony, tin, manganese, chromium, bismuth, arsenic, titanium, tungsten, cadmium, tellurium, molybdenum, mercury, silver, gold, platinum, palladium, rhodium, iridium, aluminium, osmium, cobalt, ruthenium, thallium, magnesium, indium, rubidium, cerium, glucinum, zirconium, lanthanum, erbium, didymium, yttrium, selenium, tantalum, niobium.

The following metals only showed any action: vanadium, copper, iron, and uranium. Of these LIGHTFOOT found that vanadium was the most powerful, next to this copper, next uranium, and next iron. His results were published in a pamphlet dated May 12, 1871, and it may be noted that he speaks of the action of vanadium and copper as being one which can be carried on with infinitesimal quantities, the use of larger quantities being merely an affair of convenience to save time. On October 16, 1871, Mr. ROBERT PINKNEY took out a patent for the use of salts of vanadium or uranium together, or in combination with salts of nickel for producing aniline black in dyeing and printing, and this black was to some extent introduced into practice, but the rarity of the metallic salts required operated as a bar to the large introduction of the patent. On December 24, 1874, Messrs. SELLON and PINKNEY patented improvements in producing other colours by the use of vanadium salts, in conjunction with vegetable colouring matters, such as catechu, logwood, &c. The MAGNESIUM METAL COMPANY of Patricroft being the owners of these patents, and being almost the only manufacturers of the salts of vanadium on a commercial scale in the world, have introduced the vanadium black to printers and dyers, supplying the salt of vanadium at a price which permits it to be used economically. It is probably premature to pronounce decisively upon the merits of this new black, but it may be said that many calico-printers have adopted it, whilst others do not see any particular advantage in it over the sulphide or the disulphocyanide of copper. A very interesting paper on the vanadium black, by M. WITZ, of Rouen, is to be found in the *Bulletin of the Industrial Society of Rouen*, vol. iv. p. 340, to which we refer our readers. M. WITZ has shown that exceedingly minute proportions of vanadium may be used with success, and that, by increasing or diminishing the quantity of the vanadium salt, the printer has it in his power to increase or diminish the rapidity of ageing or development of the black, and to a great extent to provide for variations in the atmospheric temperature. The following is a practical formula for vanadium black as used in England:—

No. 254. *Vanadium aniline black*:—

A.—1 gallon of water; 1½ lb. of wheat starch; boil and add 8 oz. of chlorate of potash; 8 oz. of chlorate of soda; 10 grains of vanadiate of ammonia; cool and add when going to print the following:—

B.—1 gallon of water; 1½ lb. of starch; boil and add 2 lb. of hydrochlorate of aniline.

Bronzes.—This style has been lately re-introduced by some French and English printers. The strength of the solution of sulphate of manganese, given in vol. i. p. 658, viz. 80° T., is a misprint. It ought to have been 30° T.—J. H.

CALICHE. *Native Nitrate of Soda.*—By this name the impure native nitrate of soda of Peru is known throughout South America. Dr. A. T. MACHATTIE, of Glasgow, has made the following analyses:—

	White Caliche in solid lumps	Brown Caliche containing earthy brown matter
Nitrate of soda	70·62	60·97
Iodate of soda	1·90	0·73
Chloride of sodium	22·39	16·85
Sulphate of soda	1·90	4·56
Sulphate of lime	0·87	1·31
Sulphate of magnesia	0·51	6·88
Insoluble matter	0·92	4·06
Water	0·99	5·64
	100·00	100·00

CALORIC ENGINES. (*Machine calorique, ou à air chaud*, Fr.; *Die Calorische Maschine*, Ger.) The only caloric engines which have proved to be of practical value are those working with *hot air*, *exploding gas*, and the *exploding vapour of petroleum*. The comparative merits of these different systems were determined as follows at the Vienna Exhibition:—

AIR ENGINES.

Engineers	Pounds of fuel per hour and H. P.	Relation between effective and theoretical work of fuel
BELOU	3·3–4·64	6·0–4·1
LEAVITT	6·0	3·5
LEHMANN	10·12	1·9
LAUBEREAU	9·0–13·15	2·0–1·4
ERICSSON	11·0–16·5	1·8–1·2

GAS ENGINES.

Engines	Quantity of Gas reduced to Coal in lbs.	
OTTO and LANGEN	3·96–6·0	5·0–3·5
HUGON	9·9	2·0
LENOIR	9·9–12·	2·0–1·8

PETROLEUM ENGINE.

	Petroleum in lbs.	
HOCK	1·65–2·56	8·4–4·6

It is found, on comparing different steam engines with the above motors, that they are nearly equal. The following table is arranged according to the work of the different motors:—

	per cent.
Small high pressure engine, without expansion . . .	1·3
Air engine (ERICSSON)	1·8
„ (LEAUCHEREAT)	1·8
„ (LEHMANN)	1·9
Gas engine (LENOIR)	2·0
„ (HUGON)	2·0
Portable steam engine	2·8
High pressure steam engine, with expansion . . .	3·0
Air engine (LEAWITT)	3·5
„ (BELOW)	4·1
Condensing engine, with expansion	4·5
Gas engine (OTTO and LANGEN)	5·0
Petroleum engine (HOCK)	8·4
Large steam engine, best make	9·0

The OTTO and LANGEN gas engine is very especially recommended for the performance of irregular labour.

Although the work of high pressure steam engines is less than that of gas or air engines, the cost of fuel for the latter exceeds by from 2·5 to 5 times that of the former. Thus gas or air engines have not yet been able to replace the ordinary high pressure steam engine.

Amongst other caloric engines may be named M. MOUCHOT's solar engine, water being converted into steam by the action of the sun's rays; and another, the invention of M. FOUCAULT, in which ammonia is converted into vapour by the same force. See SOLAR ENGINE.

CANDLE. (Vol. i. p. 679.) Since 1871 there has not been any importation of candles from Russia. Our *Imports* from other parts have been as follow:—

Countries	1874		1875	
	Quantities	Value	Quantities	Value
STEARINE.	cwt.	£	cwt.	£
From Holland	56,711	207,709	51,761	183,591
„ Belgium	58,001	210,097	49,877	181,492
„ other Countries . . .	3,229	12,481	3,324	9,605
	117,941	430,287	104,962	374,688
OTHER KINDS.				
From Germany	895	3,801	2,472	8,244
„ Holland	1,450	5,750	1,701	5,420
„ Belgium	1,825	6,892	1,796	6,058
„ other Countries . . .	42	214	49	245
	4,212	15,967	6,018	20,564

Our *Exports* during 1874 and 1875 have been as follow:—

Countries	1874		1875	
	Quantity lb.	Value £	Quantity lb.	Value £
OF ALL SORTS.				
To France	122,093	3,686	130,130	3,939
" Central America . . .	120,061	4,376	155,740	6,302
" United States of Colombia (New Granada) . . .	258,824	10,802	106,642	6,611
" Channel Islands . . .	106,694	6,455	325,979	8,095
" British Possessions in South Africa	958,659	31,893	841,450	27,619
" British India:				
Bombay and Scinde . .	143,830	5,082	138,467	4,849
Madras	70,780	2,441	117,450	4,003
Bengal and Burmah . .	152,790	4,822	149,287	5,879
" Australia	1,214,568	43,044	1,067,766	36,365
" British North America . .	260,602	8,899	268,484	8,618
" British West India Islands and British Guiana . .	1,106,244	37,256	1,150,310	37,231
" other Countries . . .	830,870	30,021	731,766	27,618
	5,453,753	187,777	5,315,096	177,157

Candles of all sorts exported in 1876:—4,724,980 lb., valued at 151,407*l.*

CANDLE-NUTS. The fruit of the *Aleurites triloba*, one of the Spurge family (*Euphorbiaceæ*). The tree, which grows to the height of 30 or 40 feet, is called the Candleberry Tree. It was originally a native of the Moluccas and the islands of the South Pacific Ocean, but it is now commonly cultivated in tropical countries for the sake of its nuts.

The seed of the fruit is something like a small walnut, the outer shell being very hard. The kernels of the seeds when dried are stuck on a reed, and used by the Polynesian islanders as a substitute for candles, and by inhabitants of New Georgia as an article of food.

These seeds when pressed yield a large quantity of pure palatable oil, which dries readily, and is therefore used for paint. It is known as Artists' Oil and as Country Walnut Oil.

In Ceylon it is known as Kekuna oil; and in the Sandwich Islands, where it is used as a mordant for their vegetable dyes, Kukui oil. In these islands alone not less than 10,000 gallons are annually produced.

The shelled nuts turn rancid rapidly; they acquire a yellow brown colour and a disagreeable taste. The fat extracted from them is liable to similar changes. It is sent to Europe, but used only for soap making. The oil cake is used for manure. The ash of the kernel is composed of—

Lime	18·69 parts in 100
Magnesia	6·01 "
Potash	11·33 "
Phosphoric anhyd.	29·30 "

NALLINO, *Gazetta Chimica Italiana.*

CANDLES, HYGIENIC. To M. P. L. QUARANTE, of Paris, belongs the merit—if the invention has any—of preparing candles which shall possess the property of destroying the zymotic poisons floating in the air, to which we now refer many of the diseases which afflict us. He says:—'The investigations of learned men, as to the causes of the maladies which beset and attack the human species, have plainly demonstrated that the greater part of these maladies arise from an atmosphere vitiated by spores of cryptogamia and infusoria, reduced to dust by the drying of liquids, and susceptible of reproduction in human beings and animals. Hygienic science is daily applied to the destruction, by the antiseptics which science has placed at its disposal, of these obvious morbid causes. To extend the utility thereof it is necessary to render them as practicable and as easy of application as possible. For this purpose I incorporate with the fatty matter of candles such substances as boracic acid, phenic acid, or other antiseptics, of which the portion nearest the wick of the candle in burning furnishes more oxygen to the wick and augments the brilliancy of the light.

and whose other portion, entering the fatty matter in fusion, is volatilised. In this state it destroys the miasmas which will be found in rooms or apartments the most carefully kept and purified, and will thereby keep the house in a healthy condition without any care or preparation by the occupants, who, in providing themselves with light, destroy their invisible enemies, while the volatilisation of the antiseptic does not engender any appreciable odour. This branch of hygiene applied to dwellings is destined to render great service to humanity.'

The proportion of the antiseptic incorporated with the fatty matter is ten parts for every hundred of the candle, but this may be varied according to the nature of the antiseptic employed. It will be understood that this principle may be applied to lighting by oil. For the latter purpose the lamp burner must have such a form as will permit the volatilisation of the antiseptic employed.

CANNEL COAL, *Gases enclosed in.* See COAL, GASES ENCLOSED IN.

CAOUTCHOUC, BURMAH. *Le Technologiste* informs us that a new source for this exceedingly useful material has been lately discovered in Burmah. It is hoped that by cultivation an abundant supply may be obtained, and thus meet the scarcity which has been brought about by the exceedingly wasteful process of collecting the india-rubber generally adopted.

The plant which grows in Burmah is a climber of the family of *Apocynaceæ*, bearing the botanical name of *Chavannesia esculenta*. It abounds in the forests of that country, and is cultivated for its fruit, which possesses an agreeable acidity. Another plant of this country, *Anodendron paniculatum*, likewise furnishes caoutchouc, but of inferior quality to the chavannesia. That afforded by the chavannesia is said to be very pure, and excellently adapted for commercial purposes.

That this family of plants may have been found growing abundantly in Burmah is highly probable, but it must not be regarded as a new discovery of a source for *gum elastic*.

The *Apocynaceæ*, a natural order of corollifloral exogens, mostly inhabiting tropical countries, form generally a poisonous, acrid, milky secretion; others yield a juice which is harmless, and many of them the caoutchouc. See *The Treasury of Botany*. By JOHN LINDLEY and THOMAS MOORE. LONGMAN and Co., 1876.

The caoutchouc of Borneo yields a substance of a saccharine character, which has been named *Bornesite*, having a composition $C^7H^{14}O^6$.

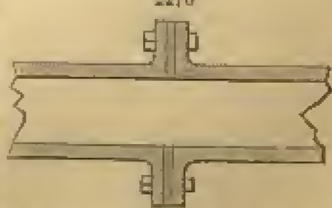
The sulphur of vulcanised caoutchouc is readily oxidised by ozone and converted into sulphurous acid.—WRIGHT, *American Journal of Science and Art*.

M. EUGÈNE PAVOUX, Director of the General India-Rubber Manufactory at Brussels, has published, in the *Revue Universelle des Mines, de la Metallurgie, des Travaux Publics, des Sciences et des Arts appliqués a l'Industrie*, an interesting description of their india-rubber works, from which the following information is extracted.

The applications of india-rubber to industrial purposes are exceedingly numerous, and are increasing daily. 'Its elasticity, its tenacity, added to which the property it possesses of being completely homogeneous and impermeable, recommend it for a vast number of uses in which it would be difficult to find a substitute.'—A. STEVART.

The various kinds of joints which are used for water pipes, gas pipes, and steam pipes, may be classed in several categories, and are all practicable with india-rubber. The flat washers for flange joints are made in various qualities of material, but most frequently by means of one or several cloths dipped in the paste, and intended to prevent the lateral extension which would take place in pressing the surfaces together, as well as by the heat, in the case of joints with steam at high pressure; the number of cloths depends upon the thickness of the washer. Instead of being parallel at the surface, the cloths are frequently disposed concentrically, and are placed at a distance from each other of from 2 to 3 millimètres.

2276



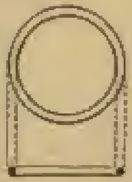
The same result may be obtained with felted india-rubber, that is to say, mixed with fibrous matter, such as woollen or cotton waste, &c., which by their resistance admit of greater tenacity, and cause the lateral extension to be less felt.

In laying the flange pipes, adjusted as shown in *fig.* 2276, it often happens that, through the negligence of the workman, the centre of the washer does not coincide with the axis of the pipe, and this causes a projection in the inside. When this defect presents itself at the lower part of a steam pipe it prevents the waste water from running off; it is better, therefore, to adopt the system represented in *fig.* 2277, where the washer is kept in its place by a flange at

one of the axis of the pipe; the play left between the two pipes admits of expansion, without causing any danger.

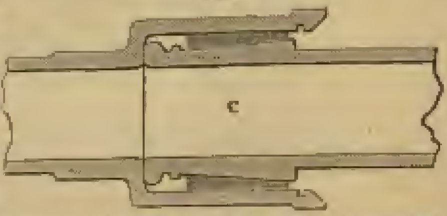
2277

2278



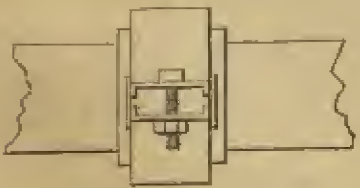
The washers with circular section which are used for joining the pipes (*fig.* 2278), are especially employed in the ingenious system of which M. Léon Somzé is the inventor. The washer is introduced by being rolled into the annular space between the two ends, called male and female, of the jointing pipes, and is kept by the conical form of the male end in a perfect state of compression (*fig.* 2279).

2279

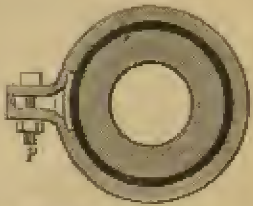


In making Delperdanges joints it is necessary to use a ring forming a band, which, placed on the flanges, which are close to each other, of two pipes is compressed and kept in its place by an iron bridle, terminating with two claws, which are pressed and brought together by a bolt. A copper sheet, *p* (*figs.* 2280 and 2281), keeps the rubber against the pipe, where the

2280



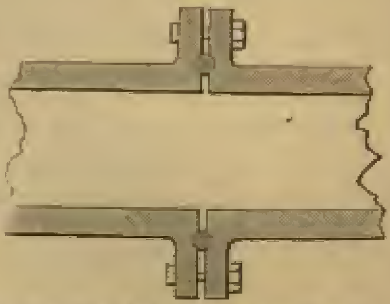
2281



claws are. *Fig.* 2280 is a view of the joint; *fig.* 2281 gives the cross section, with a lateral view of the joinings, and *fig.* 2282 represents the longitudinal section of the pipes and joinings. This system has been at work in the water distribution of

2282

2283

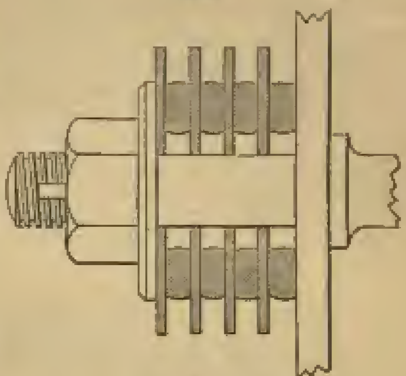


Lille and Valenciennes. Lastly, certain joints are made by means of a cord, either round or square, made of india-rubber alone or of felted rubber, which is placed in a groove of the two surfaces which have to be joined (*fig.* 2283), and when not joined,

projecting over them. The compression of this cord hermetically closes the two ends.

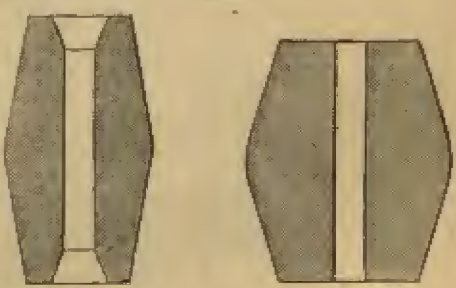
India-rubber is also largely employed in transport. On the railways, the buffers are furnished with a series of washers of rectangular shape about 2 in. in thickness, separated from each other by sheet-iron plates, which allow each washer to be compressed singly, so that every advantage is derived from the characteristic property of the material. To allow the passage of the buffer rod, these washers are pierced in the centre with a hole, the diameter of which is larger than that of the plates, in order that the depression of the washer may not drive back the rubber against the rod. For the same reason, the sheet-iron plates are of larger diameter to prevent the rubber from being pressed back beyond their outer edge (*fig.* 2284).

2284



In the construction of passenger carriages, arched pieces are used, which, being fixed in the inside of the wainscoting of the doors, receive the shock of the glass windows as they are lowered, and preserve them from the breakage to which they would be exposed without this precaution.

2285



Brussels make. Liége make.

In the tramways, the springs are replaced by buffers, taking the form of two truncated cones, united by their great base (*fig.* 2285); these buffers, placed between the box and the axles, weaken, by their elasticity, the jolting of the cars, and render the motion excessively smooth and gentle. The tenacity, strength, and duration of the springs depend on the proportion of foreign matter which the material contains; there ought to be only a small proportion, but a certain quantity is essential, in order to give them the requisite body and solidity. The use of these springs in the wagons belonging to mines and quarries would, undoubtedly, diminish the deterioration in the rolling stock by preventing the violent shocks which are frequently caused by the dilapidation of the roads.

India-rubber is also used for the outer rim of wheels for vehicles used in railway stations, large manufactories, entrepôts, &c. In this case, the metallic rim of the wheel takes the shape of a groove, in which the elastic band is embedded; the diameter of the latter is ordinarily calculated at four-fifths of that of the wheel.

Road locomotives appear to have acquired an increase of tractive power by the application of similar bandages. There is no vehicle, even down to the velocipede, which does not make use of this material, endowed as it is with so many precious qualities.

It enters largely into the construction of machines, and especially of pumps. The clappers vary in form as well as in thickness; some are round, others are square or rectangular. The seat on which they rest has several apertures, they are thus supported otherwise than on their edges, which preserves them against the pressure. The metallic brasswork which forms the seat ought to present no projecting edge, which would enter into the material and cause speedy deterioration. These clappers are, for the most part, made of simple india-rubber, but sometimes cloth is put between to give them greater tenacity. The special circumstances under which they have to be employed will guide the maker in the selection.

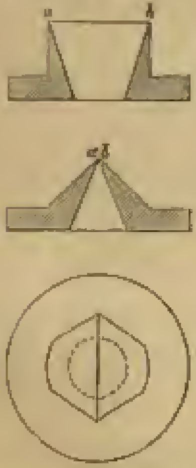
Certain valves are composed of a simple metallic sphere, covered with india-rubber,

which, being raised by the liquid, falls down again as the piston descends, on the orifice it is intended to close. In order that these valves may retain sufficient suppleness to admit of their hermetically closing the orifice, it is better that they should consist of a hollow india-rubber sphere, filled almost entirely with small shot.

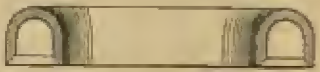
2286

An ingenious application of india-rubber is that which has been made by M. Fields, in respect to a valve composed of two india-rubber discs (*fig.* 2286), slightly conical, and placed face to face. These discs are flat and pierced with a hole in the centre, but they are compressed, and made to assume a conical shape by the metallic pieces which retain them, in the interior. Their external edges are in contact with each other, and maintained thus by the pressure which is exercised on their outer faces. The principal merit of these valves is their perfect resistance to the strongest pressure; in fact, their action being exerted in every part at the same time, the lips of the valve are forced against each other, with an energy which is greatest when the pressure is strongest. Messrs. Whitley Partners, of Leeds, have applied this valve to all kinds

2287



2288



of pumps, for pumping either cold or warm water or other liquids at pressures rising as high as ten and even thirteen atmospheres.

Perreaux valve is exclusively composed of india-rubber. The side (*fig.* 2287) goes gradually thinner until it comes to the sharp edge *a b*, which is split, and opens out a little under the pressure of the liquid inhaled; it closes again as soon as the piston begins to descend.

Hydraulic press rings made of india-rubber replace advantageously those covered with leather, which are high in price. These rings are moulded (*fig.* 2288) in exactly the form required, and they are much more flexible than leather ones, even of the very best quality.

India-rubber is well adapted for the clappers of blasting machines. The firm of Cockerill, at Seraing, use it for that purpose in their works for the manufacture of Bessemer steel. These clappers, which have to do an enormous quantity of work, last from three to four weeks, notwithstanding the eminently unfavourable conditions under which they work, and the immense wear and tear to which they are subject.

India-rubber pipes, by reason of the multiplicity of their uses, and the diversity of their composition, form an important branch of manufacture. Those that are used for gas, acids, &c., and have to bear only a feeble pressure, are made of pure rubber by simply rolling a strip of paste round a mandrel; the soldering is easily effected by contact merely, and is consolidated by the pressure of two small blades worked by hand. To prevent the paste from adhering to the mandrel, care is taken to do it over first with powdered talc. Sometimes several strips are placed one on the top of the other, the number being determined by the thickness of the pipe which is being made.

When the tubes are intended to be subjected to a certain pressure, they are consolidated by the insertion of one or more layers of cloth, the cohesion of which prevents the swelling of the pipe, the wearing away of the sides, or their rupture under extraordinary pressure. These pipes are generally formed as follows:—A round of india-rubber on the mandrel forms the first tube, over which a strip of cloth is rolled, done over with india-rubber by a calender; a fresh round of pure paste is followed by a second covering of cloth, and the operation is repeated according to the number of folds the pipe is intended to have: this number of folds depends on the diameter, and increases generally with it. The outer envelope is in india-rubber, so that the pipes seen in the diagram represent rounds of cloth completely steeped in paste. By increasing the number of rounds of cloth, we obtain pipes capable of resisting the strongest pressure.

All these kinds of tubes can only be vulcanised after they have been finished. They are put into a vehicle which runs on rails, and put into a boiler 20 yards long, specially prepared for them.

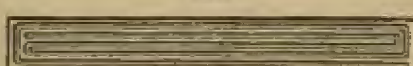
M. Favoux manufactures a particular kind of pipe, for which he has taken out a patent. It is made of tanned hemp, with an inside casing of india-rubber, and can be advantageously applied to a great number of uses. Being tanned, it is enabled to resist moisture, which has not the slightest effect upon it. It is much lighter than leather, consequently, in case of fire, a man can carry a much greater length, and can mount a ladder with it much more easily. The application of india-rubber sheets to the interior of these tubes prevents the infiltration of water into the pores of the tissue; it also prevents any loss of liquid, and protects them from injury. The resistance is very considerable; a diameter of 1¾ in. will bear a pressure of fifteen atmospheres, and one of ¾ in. will bear twice the amount of pressure. They are used for fire engines, for brewery funnels, water pipes, steam pipes, &c.

2289

The ropes used for wadding, which are made of cloth done over with india-rubber, are made without core, that is to say, without any inner nucleus in pure rubber; they are generally used concurrently with hemp for furnishing stuffing boxes, and with the best results; the flexibility of the hemp admits of the expansion of the rubber, and this, in its turn, corrects the want of compactness presented by textile fabrics (*fig.* 2289).

Straps merit special notice. They are composed of a certain number of folds of cloth done over with rubber, alternating with layers of pure rubber. The number of folds, and consequently the thickness of the strap, is in proportion to its width: for this reason, when the width is above 10 centimètres, there are at least three folds; above 15 centimètres, four folds; and above 25 centimètres they have from five to seven folds. They are made of all lengths in a single piece, and are joined exactly like those in leather. They work as well in water as in places heated to a high temperature. Their use is becoming very general, for besides being less costly than those in leather, they adhere much better. It is important that the several cloths of which they are made should not slip one over the other, and that they should be made to adhere firmly by the intermediate layers of rubber. This object is attained by their being vulcanised in the press. *Fig.* 2290 represents the section of one of these straps.

2290



India-rubber has been used for some time for covering metal rollers employed for sizing and finishing cloth; wooden rollers are replaced by metal ones, which prevents the necessity of using paper or cotton for stuffing the inside of the dressing cylinder; it also does away with the use of linen or woollen cloth for the external covering of the roller, one or more sheets of india-rubber being now used instead. Manufacturers find great advantage in this. The size, whether coloured or not, adheres sufficiently to the rubber to admit of either threads or tissues being well sized without any absorption of the material by the rubber; the size, therefore, as well as the colouring matter, can be taken off the roller by simply washing it with water, which permits the immediate use of the same apparatus for sizing in other colours. The india-rubber covering, by adhering thoroughly to the metal, and having none of those protuberances caused by the crossing of linen or woollen covers, presents a perfectly smooth and regular surface, and gives greater uniformity to the sizing. In short, the size not being in contact with the fire, in consequence of the impermeability of the rubber, there is no fear of any of those re-actions which might happen with certain colouring matter.

The thickness of the covering varies from 12 to 15 millimètres, according to the diameter of the cylinder. To have it in good order, one surface of the cylinder should be perfectly smooth.

Billiard makers secure great elasticity for their side slips by using india-rubber, to which they give various shapes at discretion. The material used for this purpose ought to have rather greater density than the raw rubber.

Our *Imports* of caoutchouc have been in 1874 and 1875 as follow:—

Countries	1874		1875	
	cwt.	Value.	cwt.	Value
From Germany	1,618	£12,024	1,686	£11,357
„ Holland	1,707	12,728	1,635	12,922
„ France	2,678	20,077	—	—
„ Portugal	3,033	31,659	2,222	21,191
„ W. Coast of Africa, Foreign:				
„ Fernando Po . .	730	6,228	1,307	10,717
„ Portuguese Possessions .	3,027	26,703	3,065	24,104
„ Not designated . .	13,207	99,937	9,423	62,632
„ Madagascar . . .	—	—	2,002	16,410
„ United States of America .	5,136	56,283	9,013	96,722
„ Central America . .	5,235	42,050	5,590	47,108
„ New Granada . . .	6,716	59,237	3,518	30,876
„ Ecuador	3,354	29,763	3,815	29,360
„ Brazil	56,580	720,210	82,245	1,015,204
„ W. Coast of Africa, British:	2,573	22,232	1,844	13,725
„ Mauritius . . .	5,934	60,000	2,726	22,930
„ British India . . .	9,611	72,163	10,417	72,090
„ Straits Settlements . .	7,101	52,878	8,509	56,401
„ other Countries . .	350	12,095	2,978	22,590
Total . . .	129,163	1,326,605	158,664	1,570,658

Manufactures.

Countries	1874		1875	
	lb.	Value	lb.	Value
From Germany	497,356	£46,807	555,163	£64,531
„ Holland	67,558	12,064	91,192	17,880
„ France	271,352	28,120	119,947	12,305
„ other Countries . .	31,516	5,055	31,485	4,261
Total . . .	868,092	93,030	777,787	99,078

Our *Exports* of caoutchouc manufactures were of the following values:—

1873.	1874.	1875.
909,287*l.*	901,703*l.*	843,440*l.*

Caoutchouc British manufactures exported in 1876 were of the

Value of . . . . 771,851*l.*

Of foreign and colonial manufacture:—

69,661 cwt. Value 630,740*l.*

CARBAZOL. A compound obtained in the purification of crude anthracen on the large scale: $C^{12}H^9N$ is its composition. The compound of carbazol with picric acid, $C^{12}H^9N-C^6H^3(NO^2)^3O$, forms beautiful red needles slightly soluble in benzene and in ether.—WATTS's *Dictionary of Chemistry*, 2nd Supplement.

CARBONATE. A name sometimes given to the black diamond or Bort.

CARBOLIC ACID. (Vol. i. p. 718.) It is recommended to be used for the preservation of meat, &c., employing 1 part in 278 parts of water.

CARBONIC ACID (dioxide of carbon, carbonic anhydride CO^2) *as a motive power.*—Since the question of employing liquid carbonic acid as a motive power has become one of interest, it is important that some notice of the means employed for producing this liquid form should be given. The ordinary carbonic acid gas (carbonic anhydride) passes to the liquid state at the zero of the Centigrade scale, 32° of Fahr., under a pressure of 38 atmospheres.

Faraday liquefied carbonic acid, by acting on carbonate of ammonia, in a sealed bent tube, with sulphuric acid, but the quantity thus produced was very small.

Thilorier used two very strong iron cylinders capable of holding about 10 parts. Into one of these cylinders is introduced 4½ lb. of carbonate of soda and 7 pints of water. A copper tube containing about 2½ lb. of strong sulphuric acid is placed vertically in this cylinder, which is closed firmly by a peculiarly constructed cock. By carefully inclining the cylinder, the acid is made to mix with the soda and water. Carbonic acid is liberated, which is condensed by its own pressure—the cylinder being kept cold—into the liquid state. After a little time the generating cylinder is connected with the second cylinder by means of a copper tube, which cylinder is carefully cooled. The carbonic acid, when the communication is opened, distils from the warm cylinder and is condensed in the cold one, so that by continuing and repeating the operation a large quantity of carbonic acid can be thus obtained in the liquid state.

Liquid carbonic anhydride (the term carbonic acid is strictly now confined to the solution of this gas in water) is colourless; it does not mix with water, but is soluble in ether, alcohol, and the volatile oils. According to Thilorier its specific gravity is 0·90 at 20° Cent., 4 below zero of Fahr., 0·83 at 0° C. 32° Fahr., and 0·60 at + 30° Cent. 86° Fahr.

Cailletet condensed carbonic acid by mechanical pressure only. Gore obtained the liquid acid in small quantities in stout glass tubes closed with gutta-percha stoppers, but the quantities thus obtained were small.

Professor Beims proposed some time since a new method for obtaining liquid carbonic acid or, as he termed it, *carboleum*. If bi-carbonate of soda be heated in an inclosed space to a given temperature, a part of the carbonic acid in chemical combination with the alkali is disengaged, and if passed into a receiver and cooled it is condensed to a liquid by its own pressure. Thus, for example, if bi-carbonate of soda be heated to about 700° Fahr. in a perfectly close and strong vessel, liquid carbonic acid of a pressure of 50 atmospheres may be obtained at the ordinary temperature of the air. Professor Beims calculates that with carboleum, as he terms it, of 50 atmospheres' pressure in the receiver, about 3½ gallons would be sufficient to do the work of one-horse power for an hour, and taking into account that, on his own estimate, about 7½ lb. of coal would be required to produce and utilise that amount of carboleum, it will be seen at once that it cannot compete with steam as used in modern engines.

Professor Beims, however, thinks that the process of producing carbonic acid and reproducing carbonate of soda might go on continuously. Supposing the carbonic acid to have been employed in moving an engine, it might be reabsorbed by the residuum of the bi-carbonate of soda; and assuming these operations to go on without fail, it will be readily seen that the receiver need only be of sufficient capacity to contain enough carboleum to keep the engine at work while the carbonic acid is reabsorbed and regenerated from the soda. Although this regenerative process is theoretically possible, it will be understood that many difficulties must be overcome before it can be of any practical utility. An attempt to utilise the discovery of Professor Beims at Vienna has been unsuccessful up to this time: it uses up at least 7 lb. of coal for every 3½ gallons of carboleum utilised in the engine.

The Americans have drawn attention to the use of liquid carbonic acid for driving torpedoes, and they have constructed special peculiar apparatus for preparing the liquid acid. The method of preparing the carbonic acid adopted at the United States Torpedo Station, Newport, Rhode Island, is not, however, adapted for use on board ship, as a compressing pump requires to be worked by a steam-engine and a freezing mixture or refrigerating machinery is also required. In the improved apparatus in the United States the freezing mixtures are dispensed with, but a steam-engine is a necessity. The latter is used to compress air to a pressure of 70 lb. or 80 lb. per square inch, which is employed to drive the pump for compressing the carbonic acid, the exhausting air supplying also all the refrigeration necessary. The gas generators consist of a couple of cast-iron vessels, one of which keeps up the supply while the other is being charged. Carbonate of lime and water is placed in the generating vessel, and a sufficient quantity of acid is permitted to enter from a vessel placed on the top, an agitator revolved by a hand wheel securing the due admixture of the ingredients. From the generator the gas is taken by means of a lead pipe through a 'washer,' containing water, to a receiver, where it attains a pressure of at least 100 lb. to the square inch. From the receiver it passes through a refrigerating vessel, and thence to the compressing cylinders, which are of steel, the pistons having small steel valves. Being already under a high pressure, the strain on the pump is much less than it would be if the gas were taken at atmospheric pressure, and the amount of compression to be done is of course less. From the pump the carbonic acid passes to the holders, vessels placed in a tank containing the freezing mixture, or in a chamber

into which the exhaust from the pump worked by compressed air discharges. After many experiments, it is found that these holders or flasks are best when made of successive layers of fine sheet steel less than $\frac{1}{20}$th of an inch in thickness. The sheets are placed so as to break joint and are soldered together with pure tin, the outer one being lapped and riveted, thus forming cylinders which are closed at each end by means of cup-shaped heads. The cost of producing the liquid carbonic acid by this means is variously estimated at from 6d. to 10d. per pound, according to circumstances and locality, and is probably the cheapest method of production at present known. The simplest method consists in an arrangement by which the reservoir is charged by means of a series of condensations, the gas condensing into the liquid form by its own pressure; but by this method a large quantity is lost by the necessity for allowing the uncondensed portion to escape at each recharging of the reservoir; where, however, the latter is small, the loss will be covered by the greater simplicity and cheapness of the apparatus.

Dr. Andrews has investigated the effect of pressure on carbonic acid at various temperatures; these researches are especially important in connection with the applications of this body as a motive power, and should be consulted. *Philosophical Transactions*, p. 575, 1869; see also Watts's *Dictionary of Chemistry*, articles Oxides of Carbon, &c.

CARBONITE. A name given to a peculiar variety of coal found in Virginia. It is called also 'natural coke.' Sir Henry Wurtz, of Hoboken, N.J., speaking of this coal, says:—'On first examination of a sample of the substance to which the name of *carbonite* has been given, my surprise was not small at failing to recognise in it one individual characteristic of true coke; neither the hardness, lustre, colour, streak, porosity, sonorosity, structure, fracture, nor any of the so-called 'pyrognostic' characters. Indeed, comparison with any coke, or variety or modification thereof, seemed out of the question. Therefore the controversy regarding supposed *trap dykes*, whose existence at the locality is denied by some, seems useless, as we have no question of a natural coking, there having been no coking at all.

'Analysis made in the usual way practised with bituminous coals, gave—

Water	0·44
Volatile combustible matter	14·08
Coke	77·17
Ash	8·31
	100·00

'Deducting the water and ash, this corresponds to—

Coke	84·57
Volatile combustible	15·43
	100·00

'On very slow and cautious heating, much of the volatile matter may be caused to escape and made to condense as an almost or quite colourless oil, mistakable for water, without much trouble, by a person making an incompetent examination. The streak of the mineral is brownish, with waxy lustre, and the powder brownish. In fine powder it is readily dissolved by hot nitric acid to a red brown liquid, after the habit of bituminous coal generally, and certainly unlike any conceivable coke.'

In a discussion on carbonite at a meeting of the American Institute of Mining Engineers, Dr. Sterry Hunt remarked:—'Mr. Heinrich stated that this coal owed its peculiar character to the original conditions of its deposition, since it was underlaid and overlaid by ordinary bituminous coal. Thus, in like manner we have layers of mineral charcoal, so called, the formation of which is apparently due to advanced decomposition before submergence. There is an instance in Silesia, where an upper stratum of coal is much less bituminous than a lower—a condition of affairs the reverse of what would have been caused by internal heat. Wormley has found, moreover, that the amount of water in samples of coal from the same bed of the Hocking Valley coal-field varies considerably.'—*Transactions of the American Institute of Mining Engineers*, vol. iii. 1875.

CARBON, SULPHIDE. This substance is a very powerful disinfectant; large pieces of veal and beef in bell-jars, containing a basin with sulphide of carbon, remained unchanged for 32 days at 15° and 24° Cent.

Fowls and pigeons, embowelled and partly plucked, kept equally well.

Baked hot meat placed in moist air containing the vapour of sulphide of carbon, did not become mouldy in 14 days.

Over-ripe plums were kept without change for 192 days. This substance stops the fermentation of a sugar solution. Urine treated with this vapour still gave the reactions of fresh urine after 18 days.—*Deut. Chem. Ges. Ber.* ix.

CARNALLITE. Crystals are obtained from the Nauheim spring which have nearly the same composition as the Hassfurk carnallite. In these Bottger found cæsium, rubidium and thallium. Hammerbacher has now treated carnallite with water, and in the resulting mother-liquor and crystals, by examining the platinum salts with the spectroscope, he has detected thallium in the crystals and rubidium and cæsium in the mother-liquor.—*Annalen der Chemie*, clxxvi.

CARPETS and **RUGS.** (Vol. i. p. 732.) See Woollen Manufactures.

CARYOTA. A genus of very elegant lofty palms. The fibre obtained from the leaf stalks, called Kittul or Kitool fibre, has great strength, and is used for making brushes, baskets, and cordage. A woolly scurf scraped off the leaf stalks is used for caulking boats. See Textile Materials.

CASK. (Vol. i. p. 744.) See Wood Working Machine.

CASSIA TORA or **TAGEREY-VEREY.** This plant produces grains known in the East Indies, Arabia, and Japan as *Tora*, but which are known in Pondicherry and other parts of Hindostan as *Tagerey-verey*. It is regularly used as a component of the indigo vat in dyeing, apparently serving the same purpose as the bran-madder or molasses used in Europe.

The native dyers use the *Tagerey-verey* in the following manner:—To dye about 200 yards of cloth, about 11¼ lb. of the grain are steeped in from 5 to 6 gallons of cold water, and then boiled for about four hours. The grains are swollen and softened by this treatment, and the water becomes thick and gummy. The whole of this is added to the indigo vat, and allowed to stand for 15 hours, when the vat is ready to dye.

CASHEW. See Catechu.

CATAPULT. (*Catapulta*, Latin.) A military engine used for throwing stones. Used in a recent patent as the name of a machine for powdering quartz by throwing the quartz stones against a disc. See Gold Quartz Granulating Machine.

CATECHUIN. A silky crystalline substance with a peculiar mother-of-pearl like appearance. Zwenger gives its formula $C^{20}H^{18}O^{8}$, Neubauer $C^{19}H^{18}O^{8}$ (*Ann. der Chem.* and *Phar.* xcvi.). This substance is much used as a dye stuff. See Crookes's *Dyeing and Calico Printing*, and Watts's *Dictionary of Chemistry*.

CATECHU, LAVAL. A name given to a new dye stuff introduced in Germany. See Dyes.

CATECHU. (Vol. i. p. 749.) A class of astringent vegetable products—which is represented by catechu—is extensively used for dyes. Several kinds of vegetable extracts, obtained by exhausting the leaves and bark of certain plants and evaporating nearly to dryness, are introduced in commerce under the names of cutch, catechu, gambier, cashew, and terra japonica.

All these are used for tanning skins and for dyeing.

The natural tints which catechu produces—varieties of brown—are modified by the introduction of metallic salts, such as iron, manganese, and copper. This last substance plays an important part in fixing the catechu (MM. C. Kœchlin and Mathieu Plessy, *Bulletin de la Société Industrielle de Mulhouse*, vol. xxii.). M. H. Schlumberger, following these chemists in their researches, found that sal-ammoniac has a specific influence in promoting the oxidation of the colouring matter of cutch and catechu by the oxy-salts of copper. Recently it has been found that the sulphide of copper can be advantageously substituted for the oxy-salts of that metal. The bichromate of potash is also used for fixing the brown of cutch and catechu. Catechu serves for dyeing bright and deep browns, fawn, drab, and wood colours. Catechu colours are often associated with garancin, producing a brownish red.—Consult *Dyeing and Calico Printing*, by William Crookes.

CEMENT. August Aigner, in the *Berg und Hüttenmännisches Jahrbuch*, part 1, 1875, pp. 124–144, thus describes the use of cement in Germany:—

'The manufacture of Portland cement is not so widespread in Germany as in England; but something resembling the English material is prepared near Kufstein from the natural marl strata of the lower Tertiary formations. Professor Fuchs, of Munich, thus explains the theory of cement manufacture:—The carbonate of lime becomes caustic on burning, and acts upon the clay in such a manner that the silicic acid is set free by means of the caustic lime, and combines with the lime upon subsequent treatment with water, producing a chemical product (hydro-silicate), the presence of alkalies by their substitution through heat favouring such reaction. Further investigators have shown that cement owes its quality of hardening to the presence of the silicates and aluminates of lime formed by the action of heat. The marl is heated in large kilns with small coal, the fire zone being in the middle of the kiln, and the proportion

of fuel to marl being as 1 to 4. The burnt material is then ground in a cement mill, and packed in casks, the cost of such hydraulic lime per cwt. being 10*d.* to 11*d.* (40 to 45 kreuzers). About Ischl the burning is carried on with wood, the cost being a trifle higher.

To manufacture water pipes from cement, equal quantities of this material and of hydraulic sand are mixed with the necessary amount of water, and this mixture is poured into the pipe moulds, the sand being previously washed and well mixed with the lime in a proper apparatus. The interior of the mould is rubbed smooth with dry graphite powder and a linen rag, an operation taking about twenty minutes. The core is then put in, the cement introduced from the mixing apparatus, and pressed down with a wooden rammer. For a 4-inch tube, 3·5 feet long, 1 cubic foot or 58 lb. of lime, and 1 cubic foot or 100 lb. of washed sand, are used. After the mould has been filled, the screws that keep it together are made tighter, to insure the cement being equally compressed throughout. The exterior form of the pipe is octagonal. During the setting, which takes place in from two to four days, the core must, for the first twelve hours, be slightly turned every half hour. After twelve hours the core may be withdrawn; and when the cement has set, the exterior walls are also removed, and the pipes transported upon their wooden basis to the drying room, where they remain sometimes sixty days. The pipes are cemented to each other by placing the ends together, and surrounding them with a mould of leather, into which more lime mixture is poured. This junction is in the form of a ring, and not angular; and as the ends of the pipes are conical, diverging outwards, the cement has no difficulty in adhering. It is obvious that the preparation of these pipes can only be conducted cheaply if inexpensive motive power (water) is available for working the washing and mixing apparatus. Under these circumstances, a 3·5 foot pipe may be made for the following sum:—

Cement (1 cubic foot)	7·0	pence
Washed sand (1 cubic foot)	2·2	,,
Graphite powder	0·4	,,
Work	6·0	,,
Sundries	1·4	,,
	17·0	

Making about 5*d.* per foot, while the price per foot of a 4-inch cast-iron pipe may be set down at 4*s.* 6*d.*

Cements for Gas Retorts.—Water glass mixed with from 3 to 4 parts of clay furnishes a very useful cement.

The poor kinds of china clay mixed with a solution of caustic soda, or a concentrated solution of carbonate of soda, form good cement. An addition to the clay of 10 per cent. of caustic, or 20 per cent. of calcined soda, is required. The mass when mixed is always ready for use, as it never hardens without heat. SEALEY's cement is said to be nothing more than a mixture of china clay and caustic alkali.—F. CAPITAINE, *Dingl. polyt. J.* ccxv.

Cements of Plaster and Lime.—The actions which occur during the setting of plaster are three, and may be seen with a microscope. These have been studied by E. LANDRIN: 1st. The burnt plaster in contact with water becomes crystalline; 2nd. The water surrounding the crystals dissolves a certain quantity of the sulphate of lime; 3rd. A portion of the water is evaporated by the heat of combination and a crystal forms, which determines the crystallisation of the whole mass. It is, however, only after some time that the mass acquires its maximum hardness, and the plaster then contains the proportion of water required by the formula **$CaSO^4$ $2H^2O$**.

Only about 12 per cent. of water should be added, as ordinary plaster always contains about 8 per cent. Yet, in practice, in France, never less than 33 per cent. is added, in order to prevent setting before the plaster can be used; the effect is to produce a very porous, slowly drying plaster, which rapidly determines nitrification.

To diminish the rapidity of setting is to delay the crystallisation, which can be effected by adding gum, gelatine, guimauve powder, glycerin, and similar bodies; while substances such as sand, sulphate of barytes, and the like, diminish the solidity of the materials without effecting the desired end.

Lime has a favourable effect on plaster, occasioning more rapid setting and giving hardness. With 10 per cent. of lime the plasters are susceptible of a polish. Samples with 75 per cent. of lime have been made; they are very hard and very light.—*Comptes Rendus*, lxxix.

The cements of British manufacture exported were as follow :—

	cwts.	Value
In 1873 . . .	4,346,334 . . .	£660,444
In 1874 . .	4,900,388 . . .	728,942
In 1875 . . .	4,910,645 . . .	642,811

CERIUM. To prepare pure cerium the following process is recommended. Finely powdered *cerite* is made into a thin paste with sulphuric acid, kept warm for several hours, then gently heated. The white powder is then exhausted by repeated treatment with boiling diluted nitric acid. The filtered solution, after treatment with sulphydric acid and filtration, is mixed with a little hydrochloric acid and oxalic acid. The oxalates are ignited in a platinum dish, with constant stirring, and dissolved in rather strong nitric acid. The solution is evaporated to a syrupy consistence, and then mixed with a large quantity of boiling diluted sulphuric acid; and the precipitate of basic ceroso-ceric sulphate is washed with hot water as long as the washings give precipitates with oxalic acid.—C. Erk, *Zeitsch. für Chem.* (2) vii.

For other processes, and for the salts of cerium, see Watts's *Dictionary of Chemistry.*

CERISE. The trade name of one of the aniline reds. It is prepared from magenta residues, and dyes shades inclining to scarlet. After the crude magenta has been boiled in water and the pure magenta deposited by common salt, carbonate of soda is added to the remaining liquid, and the precipitate thus obtained is collected and dried.

It is thought to be a mixture of mauvaniline with chrysaniline and chrysotoluedine. See Chrysaniline, vol. i. p. 803; and Aniline Yellow, vol. i. p. 187.

CERITE. *Siliciferous Oxide of Cerium.* Its composition is—silica, 21·2; protoxyd of cerium, 66·1; water, 12·7. It occurs at Bastnäs, near Riddarhyttan, in Westmanland, Sweden, forming a bed, in gneiss.

CERUSITE. *White Lead Ore.* (Vol. i. p. 757 and Lead.) This mineral, of which very fine examples have been found in this country—at Lead Hills and Wanlock Head, in Scotland; in the mines of Alston Moor, and in the lead mines of Devonshire and Cornwall—is also not uncommon in the mines of Pennsylvania and of Missouri. It has been more recently found accompanying the galena of Kirlibaba, in Bukowina, in crystals of great beauty, measuring 13 millimètres long and 7 millimètres broad, of a yellowish colour. These crystals are but slightly attached to the decomposed mica slate in which they occur, and consequently they exhibit the most perfect crystalline forms.—Zepharovich, *Jahrbuch für Mineral.*

CHAMÆROPS HUMILIS. The only European species of the palm tribe which does not extend further north than Nice. It is rarely more than three or four feet high, and in Sicily and North Africa takes the place of our furze bushes.

The leaves of this palm are commonly used in the south of Europe for making hats, brooms, and baskets, and for thatching houses. They also yield a large quantity of fibre. This palm covers a large part of the uncleared land of Algeria. The fibrous portion of the leaves is separated by a very simple process and carded. It is dyed with a mixture of logwood and sulphate of iron to give it the appearance of horsehair for stuffing furniture, for which it is largely employed.

CHALKOSIDERITE. Ullmann found this mineral as a thin crystalline coating investing the *Grüneisenstein* of the Hollerter Zug, Sayn, Westphalia (*Uebersicht der mineralogisch-einfachen Fossilien*). Similar crystals were found by Dr. Clement le Neve Foster in the West Phœnix Mine, Cornwall. The habit of the crystals is to form groups in which they are inclined to one another at slight angles, while building up a sort of sheaf, somewhat as stilbite does.

The analysis of *Chalkosiderite*, by Dr. Flight, of the Laboratory of the British Museum, gave—

		oxygen
Iron oxide	42·810	14·91
Alumina	4·449	
Oxide of copper	8·148	1·64
Phosphoric acid	29·929	17·06
Arsenic acid	0·609	
Water	14·999	
Uranium oxide	trace	
	100·944	

Which may be represented as—

$$\text{Chalkosiderite} = 2Fe^2P^2O^8 + Fe^2H^6O^6 + CuH^2O^2 + 4H^2O.$$

Journal of the Chemical Society, vol. xiii.

CHARCOAL. (Vol. i. p. 769.) A full description of the usual processes of burning charcoal is given in the volume referred to, but as some special information is given in the *Handbook for Charcoal Burners*, by G. Svedelius, we make a few extracts of interest from that work. When we consider that in America a single blast-furnace consumes daily the charcoal produced by an acre of densely timbered land, and that the United States consume, for iron making alone, the charcoal produced from 1,000 acres of forest land every week, or some 600,000 tons a year, it is seen how vast is the consumption through this channel alone. Yet it takes a generation, at least, to bring these deforested areas into bearing again, while double that time is required to bring the timber to maturity. Others have calculated that an acre of good 4-foot coal has the same calorific power as 250 acres of American forest, and that an acre of coal $\frac{1}{20}$th of an inch thick equals in heating power a year's growth on an acre of French woodland.

The following remarks on the charcoal manufacture of Sweden have an interest of their own. Our author says:—

'The timber being duly felled, cut up, and dried, the modes in which it may be charred are perplexingly numerous. There is, however, one principle which rules them all—the lower the average temperature at which the charring is conducted the better will the result be. If the process be hastened unduly, half the charcoal that might have been obtained by a slow process is wasted. Bearing this in mind, and also the correlative necessity of admitting only the minimum supply of air, we may adopt the horizontal hearth pile with chimney and covering, or the standing pile with centre block and horizontal hearth, or the lying (or rectangular) pile—as we prefer.

'One or other of these methods, or a modification of them, is always adopted in Sweden, and curiously enough they each appear to be—when properly conducted and locally modified—equally effective. The main distinction is between the standing and the lying *meiler*, according as the wood to be operated is ranged in vertical or horizontal layers. The standing *meiler* is more generally used in the north, and consists of a circular pile, in which the billets are ranged on end round a central wooden chimney, in which the fire is kindled, the whole being covered by a thatching of brushwood or turf, on which is packed a layer of charcoal dust (or, in default, sawdust or dirt) to exclude the air. The hearth, or ground on which the wood is piled, is an object of the greatest solicitude to the careful charcoal burner. The hearth-ground should be dry, solid, and free from draught. The more it is used the more valuable does it become, and it is ruled that when a good hearth is found it should never be deserted, even though in process of time—the trees of the vicinity having been consumed on it—wood has to be hauled to it from a distance. That the hearth should be in a position where water will not stand at any season, though a supply should be near at hand, is considered indispensable. The pile being once alight, the attention of the charcoal burner is directed to keeping up just sufficient draught to maintain the combustion, which is effected by making small orifices in the dust covering: these, however, must be stopped, and opened in a fresh place, when the wood adjacent to them is charred. The rule to be observed is that the draught be led through the unignited fuel from the point at which the fire was kindled. Smoke vents, to prevent explosions, have also to be cautiously opened, and the covering, which is apt to fall in, maintained, and for the two or three weeks during which the process lasts a constant watchfulness has to be maintained. As, however, the actual labour required, when once the pile is erected, is small, it is economical to have several piles burning simultaneously close together, so as to be under the charge of a single operator. When the charcoal is removed from the pile, it is important to stow it at once in sheds, as it deteriorates rapidly by exposure to the weather.'

Foucauld introduced a process in which the troublesome dust and brushwood covering of the *meiler* is replaced by strong wooden frames covered with loam, which can be readily taken to pieces and transported from place to place when one locality has been exhausted. In a somewhat similar system, that of Dromart, the wooden frames are replaced by a sheet-iron casing constructed in sections, which can be readily put together wherever a suitable hearth site is found.

Charcoal from Seaweed.—At Noirmoutiers more than 200 *fourneaux* are constantly at work manufacturing seaweed charcoal. This charcoal is valued at from 50 centimes to 1 franc per hectolitre. 100,000 kilos. (of 2,204 lb.) of fresh weed will give

20,000 kilos. of dry material, or 5,000 kilos. of charcoal, which, when incinerated, yield from 3,500 to 4,000 kilos. of saline matter.

Seaweeds which abound in potash, as the *Laminaria*, contain more iodine than bromine. In *Fucus nodosus*, *F. vesiculosus*, and *F. fructicosus*, soda predominates and bromine is more abundant than iodine.—*Les Mondes*, May 1876. See SEAWEED.

CHAULMOOGRA OIL. An oil extracted from the seeds of the *Gynocardia odorata*, an East Indian tree, abundant in the hot valleys of the Sikhim Himalaya.

The pure oil has a sp. gr. of 0·9. If prepared by means of heat, the oil turns first of a burnt sienna colour, changing into olive-green with acids.

The seeds are beaten up with clarified butter and used by the natives as a remedy for cutaneous diseases.—W. DYMOCK, *Pharm. J. Trans.* vi.; see *The Treasury of Botany*.

CHEESE. In making Roquefort cheese BLONDEAU found that the casein can be converted into a fatty substance by the common mildew fungus (*Penicillium glaucum*).

Swiss Cheese is thus made:—The milk in large copper pans is treated with rennet, and a gelatinous mass is obtained. The whole is left to itself for a quarter of an hour, and is then stirred up until the mass is broken into small pieces about the size of a pea, when the pan is heated to 55° with stirring for an hour. The whole is subjected to pressure and the whey separated. The mass is then placed in a cellar, and allowed to remain at a temperature of 10° or 12° C.

The outside is daily rubbed with salt until it is removed into the warehouse, and left to ripen slowly.

F. COHN writing in *Dingl. polyt. Jour.* says: 'The ripening of the cheese, by which the white, sweetish mass gradually attains the desired pungent taste and colour and translucent consistency, is a genuine fermentation, taking place under the influence of ferment organisms. The fermentation begins in about 24 hours, and is accompanied by a free evolution of carbonic acid.

COHN thinks that the retention of the whey in the cheese is advantageous, its lactose being converted by zymophytic fermentation into butyric acid.

CHESSYLITE. Azurite or *Blue Carbonate of Copper* in New South Wales is found massive and crystallised. The best specimens of the latter come from the Cobar Mines. They often assume a radiated concretionary form, with the terminal planes of the crystals studding the surface of the balls in the form of small projections. These concretions vary from almost imperceptible points up to balls several inches in diameter, and as they often occur diffused through a pale grey or green-coloured steatitic clay, they present an extremely pretty appearance; at other times the crystals are set off by a dazzling white felspathic clay. Well-developed crystals are also found lining vughy cavities.

At Cobar, Chessylite is associated with atacamite in addition to the other more commonly occurring ores.

At Woolgarloo, Chessylite occurs with native copper, cuprite, and malachite in pink and white fluor spar. This mixture has at times a pleasing effect, from the manner in which the copper minerals are diffused through the cracks and reticulating cavities in the fluor spar. Something of the same sort of thing is to be seen in the fluor spar from South Wiseman's Creek.

Amongst other localities in New South Wales for Chessylite are Inverell, in quartz veins; Bathurst, Peelwood, Icely, and Ophir.

CHINA CLAY. See CLAY.

CHLORINE. (Vol. i. p. 789.) In manufacturing chlorine by Deacon's process (vol. i. p. 790) it is found that the yield of chlorine, which is abundant at first, becomes after a time less and less, until it is reduced to almost nothing. This appears to be due to absorption by the clay balls of the sulphuric acid always present in the gases operated on. R. HASENCLEVER examined some clay balls which had ceased to act and he found in them 1·2 per cent. of copper, and 8·0 per cent. of sulphuric acid, whereas balls freshly saturated with sulphate of copper contained 1·2 per cent. of copper and 1·5 per cent. of acid only.

In the manufacture of sulphate of soda the hydrochloric acid set free is evolved partly from the pans in which the sulphuric acid and salt are first mixed, and partly from the ovens in which the mixture is afterwards heated, the gas from the ovens always containing much more sulphuric acid than that from the pans. It is found in practice that in those factories where the gas from the pans alone is used for the preparation of chlorine by Deacon's method the process goes on for many months with the same decomposing materials, but when the gas from the ovens is also used, the activity of the materials ceases much sooner. M. R. HASENCLEVER proposed to absorb

the sulphuric acid, and to use the purified gas for the preparation of chlorine.—*Deut. Chem. Ges. Ber.* ix. p. 1070.

CHLORIDE OF LIME. At page 781, vol. i. the processes usually employed for the manufacture of Bleaching Powder are given. There are a few points, the results of enlarged practice, which require a brief notice in this place.

Mr. WELDON has proved the possibility of substituting magnesia for lime in his method of regenerating manganese, and this possibility formed the basis of his experiments upon a manufacturing scale, carried on while manufacturers were debating the relative value of rival processes.

Before considering the modified process, it will be as well to examine the condition of the chlorine manufacture previously to WELDON'S experiments.

The more important processes were those of OXLAND, of MAUGHAN, and TESSIE DU MOTHAY. OXLAND passed one volume of dry hydrochloric acid and two volumes of air through air-tight reverberatory furnaces, packed with pumice stone at a red heat, and chlorine in a diluted state was obtained. MAUGHAN proposed to pass hydrochloric acid through manganese contained in cylinders heated by steam—the evolved gases being washed in water, and the chlorine being conveyed to the chamber. TESSIE DU MOTHAY kept peroxide of manganese at a red heat in a retort—sometimes he mixed lime with it—and then caused a current of hydrochloric acid gas to pass through it; chlorine and steam are disengaged, and there remains in the retort a mixture of undecomposed peroxide of manganese with chlorides of manganese and calcium. Over the mixture remaining in the retorts still at the same temperature air or oxygen is passed, which in the presence of the peroxide is said to decompose the manganic chloride at once.

DEACON patented a process which consisted in passing sulphuric acid and air over salt at a high temperature. The chlorine liberated was, however, too much diluted. LALANDE and PRUDHOMME professed to have improved this process by employing silicic, boric, and phosphoric acid, and alumina, but, although these processes were of much scientific interest, they were not of much industrial value.

Mr. WALTER WELDON was the first to revive the spent manganese by effecting aërial oxidation. Mr. KINGZETT in his excellent book on 'The Alkali Trade,' informs us that out of 90,000 tons of chloride of lime manufactured, more than 50,000 tons were made by WELDON'S process; that 22 plants were working the process, and 40 others were in course of erection in 1877. The process was also largely employed in Germany, France, and Belgium.

The following matters are worthy of every consideration:—

The quantity of lime which it is necessary to employ in the oxidiser varies considerably, because lime dissolves in chloride of calcium, and further because all parts of the lime do not act equally well—the coarser particles act less rapidly and perfectly. Usually, however, 1·15 to 1·45 equivalents are added before the precipitation of *all* the manganese, and the further known quantity is such that the foregoing figures become 1·5 or 1·6 equivalents.

In the presence of an excess of lime there is not obtained peroxide of manganese, but, as WELDON suggests and claims to have demonstrated, various compounds of the peroxide with lime, viz. manganites and sesquimanganites, &c. Thus $CaOMnO^2$ and $CaO2MnO^2$ are obtained, a small portion of the CaO being usually replaced by an equivalent amount of MnO. The quantity of air required to be blown in varies with the conditions, chiefly depending upon the depth of the oxidiser—the greater the depth the more rapid the oxidation proceeds. In one instance 175,000 cubic feet of air were blown in during five hours, and of the oxygen contained in this, 14·5 per cent. (equal to rather more than 4 cwt.) was absorbed in the production of 22 cwt. of peroxide of manganese (MnO^2 Weldon). The mechanical power generally expended in blowing averages about between seven and eight horse-power for one hour, per 100 pounds of MnO^2 made.

Theoretically, 1,020 lbs. of MnO^2 should yield the amount of chlorine contained in 1 ton of bleaching powder per 37 per cent. chlorine, and in practice 1,100 lb. of MnO^2 are necessary for this production, or rather that amount of mud containing 1,100 lb. MnO^2. The lime used is generally prepared like that used for making bleaching powder, and its consumption averages 14 cwt. per ton of bleach. By this process 1 ton of bleach is made, using 2,832 lb. of hydrochloric acid (HCl), generated by the decomposition of 47·5 cwt. of salt, viz. a quantity which theoretically yields 3,331 lbs. HCl. There is, therefore, a loss of acid of 15 per cent. The loss of manganese varies from 4 to 10 per cent. The whole of the lime is lost, and two-thirds of the total chlorine (in combination with calcium) contained in the acid used.

Mr. VALENTIN, of the Royal School of Mines, discovered that ferricyanide of potassium acted as a carrier of oxygen to protoxide of manganese, and he proposed to apply

this discovery to this industry. For this purpose the still liquors, after neutralisation with lime, are precipitated by a chemical equivalent of lime, and instead of adding more lime, as is done in Weldon's process, a solution of potassic ferricyanide is added, and is blown through, whereby the protoxide becomes peroxide of manganese, and in much less time than with Weldon's process.

It is probable that the influence of the ferricyanide consists in yielding up its oxygen to the mud, being at the same time reduced to ferrocyanide, and this being reconverted into ferricyanide, these reactions are continually repeated until the whole of the manganese is peroxidised. To effect this, it was found that about 10 lb. of the ferrocyanide were requisite per ton of manganese mud, and Mr. VALENTIN calculated that this form of process would yield 'bleach' at about 10s. per ton cheaper than Weldon's process. Unfortunately, a difficulty was encountered. It was necessary that the ferrocyanide should be recovered for two reasons—viz. on account of its cost, and to prevent cyanogen compounds entering the chamber with the chlorine; and to recover the ferricyanide it was found necessary to filter the mud, an operation which on so large a scale was found to be impracticable. This process of Mr. Weldon's is fraught with interest apart from its industrial value. We have seen that its inventor claims to have proved the formation of manganites—that is, bodies which may be viewed as salts in which the base is calcium or manganese protoxide, and the acid radical manganic peroxide; thus, $CaOMnO^2$ and $MnOMnO^2$; and possibly also $(CaO, MnO)(MnO^2)^2$.

The great interest of the process attaches to the high state of oxidation attained by the manganese. If air, or even oxygen, be blown through protoxide of manganese suspended in solution, only the sesquioxide is formed (Mn^2O^3); but, as before said, if this oxidation be effected in the presence of ferricyanide of potassium, peroxide of manganese (MnO^2) is produced. Mr. VALENTIN explains this as a process in which the ferricyanide acts as a carrier of oxygen, and it is instructive to compare this reaction with other similar ones known to chemical science.

Suboxide of copper, or cuprous oxide Cu^2O, is a red body, and tolerably stable in the pure state at normal temperatures. When dry, it passes into a higher state of oxidation if heated to a temperature considerably above 100° C. If placed in water and submitted to a current of air or oxygen, it is unaffected, as the writer has shown; but the presence of a small quantity of a caustic alkali under these conditions induces a peroxidation even in the cold, and more rapidly in the hot; and in this way the red lower oxide is transformed into the black oxide, CuO. Here, therefore, the alkali acts as a carrier of oxygen, and this hypothesis derives considerable support from Harcourt's discovery of higher oxides of potassium and sodium than that which forms the base of ordinary caustic alkaline solutions. It is, therefore, to be supposed that in the above reaction the oxide of sodium or potassium is, for the time being, continually peroxidised and reduced, yielding the oxygen thus carried to the oxide of copper.

WELDON'S *Magnesia Chlorine* process, a still further improvement, is thus described:

'The process commences by neutralising the acid liquor from the stills, formed by the action of hydrochloric acid on native manganese, with Greek stone or very nearly pure magnesite (carbonate of magnesium). Or, if it be desirable, the Greek stone may be first calcined, and the light, easily dissolved magnesia powder, so made, used in its stead. This operation is performed in a well of cast-iron, or the liquor may be neutralised in the stills.

'The mixed chlorides of manganese and magnesium liquor, obtained as described, is pumped into the settlers, where any peroxide of iron, alumina, and gypsum deposit. This gypsum is derived from the sulphuric acid contained in commercial hydrochloric acid. From the settlers the liquor is run into an iron pot or pan, where it is evaporated until it attains a state of concentration, registering a temperature of about 320° Fahr. At this stage the evolution of hydrochloric acid gas commences, from the decomposition of the magnesic chloride by water. By opening a screw plug (of metal) it is now run into a muffle furnace, consisting of two divisions, which communicate with each other by means of an iron door worked by a pulley from without.

'In one of these compartments the evaporation to dryness is completed, and is accompanied by the evolution of much hydrochloric acid, *plus* a little chlorine. The residue, which, by stirring constantly at this stage, is broken up into thin cakes, is now transferred by means of a rake into the second compartment, where it is heated with access of air.

'Here the heat requires careful regulation, for if the temperature rises too high, fusion ensues, and thus the porosity of the mass is lost and oxidation impeded. The best heat is one designated "blood-red," and if this be attained and kept, the oxidation proceeds very regularly till the end. This tendency to fuse on the part of the

mixture is due to the magnesic chloride, and therefore it is greater in the first place than afterwards, when it is partially decomposed, as magnesia exhibits no such disposition. In other words, the furnace may be brightly red hot in the first compartment, because the temperature is greatly reduced by the evaporation which there takes place. As the mixture passes into the second compartment of the furnace it consists of manganese chloride, together with magnesic chloride and magnesia; hence it is at this stage that the temperature must be carefully watched, but as the decomposition proceeds, the magnesic chloride becomes less and less in quantity, and therefore the temperature may be allowed to increase with the decomposition to some extent. At the same time that the magnesium chloride undergoes decomposition, so also does the manganese chloride, and there is thus obtained protoxide of manganese, which absorbs oxygen from the air which is admitted, and becomes peroxide. This latter body appears to combine with the magnesia under these circumstances, and forms what WELDON has termed manganite of magnesium ($MgMnO^3$), which, when properly made, is a dense, black, finely divided powder. It should be understood, however, that all the manganese is not peroxidised; in short, that there remains a certain portion as protoxide, and this, with the magnesia, constitutes what is termed the "base," that is, it furnishes with hydrochloric acid no free chlorine. It is only the manganese which exists as peroxide that is capable of liberating chlorine in the stills. Now, so long as water is present in the furnace, hydrochloric acid is evolved, and as the main evaporation takes place in the first division of the furnace, it is chiefly hydrochloric acid which is there generated. In the second division it is chiefly chlorine which is evolved, but it is of course mixed with some hydrochloric acid.

$$MgCl^2 + H^2O = MgO + 2HCl$$
$$MnCl^2 + H^2O = MnO + 2HCl$$
$$MnCl^2 + O = MnO + Cl^2$$
$$MnO + MgO + O = MgMnO^3$$

These equations probably represent the reactions in the order in which they occur in the furnace. It is indeed doubtful whether much manganese chloride is decomposed by the water, so long as there remains any chloride of magnesium, as this latter body is far more readily decomposable. Any water left would then attack the chloride of manganese, and finally the mixture of oxides of manganese and magnesia absorbs oxygen to form the compound manganite of magnesium. Of course, to a certain extent, all these reactions take place at the same time, but not in the same measure. Portions of the charge may be withdrawn from the furnace from time to time and tested for the amount of manganic peroxide, and when this amount ceases to increase the operation is concluded. The charge is now withdrawn, and is placed in the stills when cold, there to decompose a renewed quantity of hydrochloric acid, giving undiluted chlorine, and the liquor so obtained is perfectly neutral, or may be made so by addition of a little magnesia, and is then ready to pass through the cycle of operations already sketched. And so the process is repeated *ad infinitum*, without being attended with any waste product whatever.

"The manganite of magnesium may be charged into the stills in one of two or three ways, namely, either in the state in which it comes from the furnace, or in the form of a sludge made by grinding it in a mill with water, or it may be added gradually through a valve so constructed, that while it admits the charge it does not allow of the escape of the chlorine. In any case it is always charged in slight excess, so that there results a practically neutral still liquor. This liquor is allowed to settle somewhat before drawing off, so that any excess of the furnace product left undecomposed is not lost, but remains in the still for a subsequent operation.

"Now, we have seen that of all the chlorine formed in this process, that generated in the still is alone undiluted, whilst that evolved in the furnace is mixed with much hydrochloric acid and nitrogen from the air, together with that excess of air that may have been used in the process of fire oxidation (or *peroxidation*). The *mixed* gases are drawn by chimney draft through the "coke scrubbers" in the ordinary way (see Salt-cake chapter), by which means the hydrochloric acid is washed out, thus giving a product strong enough to serve the purpose of reacting upon fresh manganese in the still. Evidently several courses now present themselves for dealing with the dilute chlorine. In the first case the strong chlorine can be used at once in the old chambers, or it can be mixed with the dilute gas, producing a gas of sufficient strength to form "bleach." On the other hand, the weak chlorine admits of a process which effectually removes the air and the nitrogen. This was carried out on a manufacturing scale in St. Helen's, by introducing the gases into leaden towers from below, where they, in their ascent, meet with a shower of milk of lime, which unites with the chlorine, forming at first ordinary "bleach liquor," but which, on the absorption of a further

amount of chlorine, produces a liquor containing only chloride of calcium and free hypochlorous acid, thus:—

$$CaCl^2 + CaCl^2O^2 + 2H^2O + 2Cl^2 = 2CaCl^2 + 4HClO$$

'Assuming that such a liquor could be constantly obtained of this composition, it could be utilised in two or three ways. First, it admits of being pumped direct into the "octagons," where it is treated hot with chloride of potassium, to make chlorate of potassium; or it may be placed in the still and treated with hydrochloric acid, when the following reaction occurs:—

$$4HClO + 4HCl = 4H^2O + 4Cl^2$$

That is to say, the hypochlorous and hydrochloric acids mutually react, giving rise to free chlorine and water. The chloride of calcium takes no part in the reaction, and is lost. But here is the danger of the process. It is a difficult thing to keep down the temperature in the towers where the chlorine is absorbed by lime milk, and when the temperature rises above a certain height, chlorate of calcium is formed, and the presence of this body in the liquor might, if used in the stills, give rise to very serious explosions on account of the explosive nature of the oxides of chlorine there liberated in such a case. Moreover, the action of hydrochloric acid upon hypochlorous acid is terribly violent, and attended with danger. This danger is obviated, however, in great measure by running the hypochlorous acid solution in a thin stream into the hydrochloric acid contained in the still. We have in Chapter XIII. referred to my discovery of calcic hypochlorite, and shown that in the future manufacturers may possibly seek to make this body instead of bleaching powder. This could only be done, so far as we know, in one way, and that at present a difficult one. If it could be successfully accomplished, it would at once employ the liquors of which we have been treating above. Thus, in the towers, where the milk of lime is exposed to the chlorine, we should have to stop at that stage where "bleach liquor" results, and avoid the formation of hypochlorous acid. The reaction in that case would be as follows:—

$$2CaH^2O^2 + 2Cl^2 = \overbrace{CaCl^2 + CaCl^2O^2} + 2H^2O$$

This liquor, as we have shown, gives, on evaporation in vacuo over sulphuric acid, a crystallisation of pure hypochlorite of calcium, leaving the very soluble chloride of calcium in solution. Now, if such an evaporation could be conducted on a manufacturing scale, so, surely, might this process assume the extent of a trade. Unfortunately, heat cannot be employed to concentrate the liquor, for in that case, as we have seen, calcic chlorate results.

'Leaving this part of our subject, Mr. Weldon claims to be able to produce, by the manganite of magnesium chlorine process above sketched, 1 ton of bleach per 16 cwt. of salt used (to generate the hydrochloric acid). "This is about *four times* the average yield," says Mr. Weldon in a manifesto of February 6, 1872, "obtained at present."

'Further, by varying the proportions of chloride of manganese and of magnesium, it can be so arranged that "the proportion of the strong chlorine generated in the still, to that of the weak chlorine produced in the furnace, may be anything between one to one and one to four, at will."

'The process is continuous, and requires, from its simple character, but little skilled labour. No machinery (excepting liquor pumps) is involved; the plant required is comparatively low in cost, compared either with the Weldon process in general use or Deacon's process, and Mr. Weldon claims for it the production of "bleach" at a less cost per ton than by any other process, even throwing the whole cost on the strong chlorine only. These, however, are matters which, in event of the process being adopted, would require a more extended experience to decide with certainty.'—*The History, Products and Processes of the Alkali Trade*, by Charles Thomas Kingzett.

The following table is employed in works where Weldon's process is in use, for the estimation of the 'base,' that is the CaO and MnO in the mud.

As the number of grains of ferrous sulphate ($FeSO4\ 7H^2O$) peroxidised by the MnO^2 in a given volume of manganite mud is to the number of grains of oxalic acid ($C^2H^2O^4\ 2H^2O$) decomposed and neutralised by the same volume of the mud; so is 100 to a figure in column A against which in column B is the per cent. of bases:—

A				B			
69·00	65·75	62·50	59·25	1·044	·901	·758	·615
68·75	65·50	62·25	59·00	1·033	·890	·747	·604
68·50	65·25	62·00	58·75	1·022	·879	·736	·593
68·25	65·00	61·75	58·50	1·011	·868	·725	·582
68·00	64·75	61·50	58·25	1·000	·857	·714	·571
67·75	64·50	61·25	58·00	·989	·846	·703	·560
67·50	64·25	61·00	57·75	·978	·835	·692	·549
67·25	64·00	60·75	57·50	·967	·824	·681	·538
67·00	63·75	60·50	57·25	·956	·813	·670	·527
66·75	63·50	60·25	57·00	·945	·802	·659	·516
66·50	63·25	60·00	56·75	·934	·791	·648	·505
66·25	63·00	59·75	56·50	·923	·780	·637	·494
66·00	62·75	59·50	56·25	·912	·769	·626	·483

CHONDRODITE. From χόνδρος, Gr. a grain, in reference to its granular structure. The following analysis of this mineral from Eden, near New York, is by THOMSON:—

Magnesia	54·64
Silica	36·00
Protoxide of iron	3·75
Fluorine	3·97
Water	1·62
	99·98

The only locality in these islands for this mineral is Loch Ness, in granular carbonate of lime, with magnetic and arsenical pyrites.—*System of Mineralogy*, by JAMES D. DANA; *Glossary of Mineralogy*, by H. W. BRISTOW.

CHORISIA. A genus of small prickly-stemmed plants peculiar to South America. The tough bark of *C. crispiflora* is used in Brazil for making cordage, and the cottony hairs of *C. speciosa* of the seeds are used for stuffing pillows. The tree is known in Brazil by the name of Arvore de Paina.

CHROMATE OF LEAD. *Manufacture of Persian Red from it.* See PERSIAN RED.

CHROME, *certain Reactions of the Salts of.* (Vol. i. p. 797.) M. A. ETARD, in the *Comptes Rendus* for May 24, 1875, has a paper on this subject. He states that at present the reactions are not known by which the salts of the sesquioxide of chrome can be converted instantly and at will from one modification to the other.

The green salts only become violet under the influence of nitric acid after the expiration of a longer or a shorter time. Certain reagents produce an immediate effect. The green salts become a carmine violet if mixed in the cold with a little nitrite of potash.

The carmine tint developed at the moment of the mixture of the two solutions, and which resembles that of the amido-chromic compounds, gradually disappears to give place to the blue violet, which has chrome alum for its type.

Sulphocyanide of potassium produces the same phenomena, but more slowly.

The green solutions of chrome, if precipitated by potash, give a hydrate insoluble in ammonia, and which, if redissolved in acetic acid somewhat concentrated, takes a carmine-violet colour. In this case the carmine tint does not pass into the violet-blue in course of time.

Under the influence of the arseniates, or of free arsenic acid, the violet salts become a bright green in a few seconds in the cold, and cannot be brought back to a violet by the nitrites.

LŒWEL admits four modifications of hydrate of chrome—two green, one violet-carmine, and one violet-blue.

The violet-carmine salt obtained with a nitrite gives with potash a grey precipitate insoluble in ammonia, which distinguishes this salt from the ordinary one, violet-blue salt.

The light green salt obtained with the arseniates has the equally characteristic property of giving with potash a precipitate insoluble in acetic acid, and soluble in ammonia with a violet-blue, a reaction exactly opposite to that of the ordinary deep green salts.

CHROME IRON. (Vol. i, p. 799.) *In New South Wales.* It usually occurs massive, with a granular or lamellar structure. Black in colour, and in small crystals and water-worn grains in gold and gem bearing sands.

In the Gwydir river and many of its tributaries, in Nandle Creek, Two-mile Creek, the Horton river, Hanging Rock, at Stony Batta with serpentine, Bingera, Reedy, Gundamulda, Kennedy's, and Angular Creeks; also at Mudgee, the Murrumbidgee river, and near Yass.

M. Seemon Kern, of St. Petersburg, states that an alloy obtained by melting in graphite crucibles 315 parts of chrome ironstone from the Ural Mountains with 200 parts of charcoal powder and 70 parts of lime as a flux, was of a silver white fracture, and was so hard as to cut glass with ease. Chemical analysis proved this alloy to contain 74 per cent. of chromium, with 25 per cent. of iron.

Another alloy, containing about 97½ per cent. of iron, with 2½ per cent. of chromium, was found to be malleable, and could easily be bent.

Since the analyses of chrome iron ore seldom give more than 60 per cent. of oxide of chromium, it appears unlikely that, under any metallurgical treatment, an alloy containing 70 per cent. of chromium could be obtained.

General Carrington read a paper on chrome steel in Section G of the British Association, in 1875. Nothing more than the title of the paper is given in the Report of the British Association, but an abstract appears to have been given in the *Engineer* for September 10, 1875.

Chrome iron ore is sometimes met with in minute octohedral crystals, which may be mistaken for magnetic iron sand, but it may be at once distinguished by not being magnetic.

In the preparation of the oxyd of chrome used in painting, and the chromic acid salts, about 2,000 tons of chrome ore are used annually in this country. It is chiefly derived from Baltimore, Drontheim, and the Shetland Islands.

Chrome Ore Analysis.—One part of very finely powdered ore is heated to bright redness for about an hour in an open crucible, with repeated stirring together with two parts of pure calcined soda and three parts of slate lime. The latter is prepared by adding to burned marble water sufficient to cause it to fall to powder. After cooling the chromate is dissolved out with hot water.—R. Kayser, *Zeitschr. Anal. Chem.* 1876.

Blowpipe Reaction.—Chromium compounds form, when fused with carbonate of soda, a green enamel not unlike that produced by manganese; but the chromium bead never exhibits a tinge of blue, as that of manganese does. If saturated with vitrified boracic acid until all the carbonic acid is expelled, a chrome glass is formed which will retain its green colour, whilst the manganese glass will become amethystine or violet. (Chapman.)

CHROMEISEN. It is well known that the metal chromium is very hard, and even scratches hardened steel. A chrome iron alloy can, however, be formed which is malleable. It is produced by melting chrome iron with some scrap iron in crucibles. Sometimes nothing but slag appears, but on breaking up the slag an alloy is found at the bottom, the average composition of which is—

Metallic iron	96·40 per cent.
Metallic chromium	2·30 "
Carbon	traces
Lime and silica	1·30 "

It is stated that by using chromeisen instead of spiegeleisen very soft steel is obtained.—*Chemical News*, xxxii. pp. 130, 266.

CHROME GREEN. See Green, Guignet; Green, Ultramarine; Green, Leune, and Castelhaz's Green-Arnaudon, and Green, Mathieu Plessy's. If one part of bichromate of potash and three parts of baked gypsum—scagliola—are intimately mixed and strongly calcined, there results a grass-green mass, which, on boiling with water or on mixing with diluted hydrochloric acid, leaves a fine powder of an intense and beautiful green, possessing a very high colouring power. This is a process recommended by Apolto Casali.—*Gazetta Chimica Italiana.*

CHROMIFEROUS SERPENTINE.—Mr Selwyn, the Director of the Canadian Geological Survey, thus describes this mineral:—

'Associated with chromic iron, in the townships of Bolton and Melbourne, there occurs a mineral which has long been supposed to be kämmererite—a mineral related in chemical and optical characters to penninite. A specimen recently examined, however, has rather the composition of an aluminous serpentine. It is massive, or slightly foliated; greasy to somewhat pearly in lustre, and translucent to sub-translucent; the colour is pale violet by reflected, and somewhat deeper violet by transmitted light;

feels almost as greasy as that of talc; hardness only 2. The specimen analysed was found to contain—

Silica	43·04
Alumina and ferric oxide	5·69
Chromic oxide	0·67
Lime	1·22
Magnesia	34·80
Water	14·54
	100·66

In appearance the mineral resembles some of the varieties of kämmererite from Texas, Pennsylvania. The latter mineral, however, contains much less silica, and a far larger proportion of alumina.

CHROMIUM. (Vol. i. p. 801.) E. Leitnow, in the preparation of this metal, uses, instead of the mixed chlorides of potassium and sodium recommended by Wöhler, a double chloride of chromium and potassium. He forms this double salt from the red chromate of potassium by reducing it with hydrochloric acid in the presence of alcohol and adding chloride of potassium to the boiling liquid, which is then evaporated to dryness. The residue, after being carefully dried, is mixed with finely granulated zinc, and this mixture is introduced by successive portions into a red-hot Hessian crucible, in which after the last portion has been added, it is heated for three-quarters of an hour, and then allowed to cool slowly. The soluble salts are dissolved out by water, and the zinc by dilute nitric acid.—Poggendorf's *Annalen*, cxliii.

CHROMLEIM. *Chrome Glue.*—A strong solution of gelatin (5–10 per cent. dry gelatin) is made, to which, for every 5 parts of gelatin, about 1 part of acid chromate of potash in solution is added. This mixture possesses the property of becoming insoluble in water by the action of sunlight. The broken portions of any fractured vessel are coated with a freshly prepared solution, pressed together and fastened with a string; the vessel is placed in the sun, and after a few hours it is firmly mended. H. Schwarz says even hot water cannot dissolve the glue.

(It does not appear to me that the change described in the chrome glue can take place throughout the layer of it, which extends through the crack. The two edges in a crack are covered with this chromleim; they are pressed together and exposed to the sun. It is the light, and the light only, which effects the change producing insolubility, therefore all the parts in the dark, in the inner parts of the crack, cannot undergo the change.)

Chrome glue may be used to render paper and other articles waterproof. The material, of whatever kind, is fixed in a frame and carefully coated two or three times with the solution and then exposed to light. Knapsacks and other things may be covered with linen rendered waterproof by this cheap and simple method.

In preparing *carton-pierre* for roofing it is recommended that this chrome glue should be used. It is said, a roofing thus prepared was exposed to one year's heavy falls of rain without being damaged. See *Dingl. polyt. Jour.*, ccxviii.

CHRYSENE ($C^{18}H^{12}$) was discovered by Laurent in crude anthracene. For the derivatives of chrysene, see Watts's *Dictionary of Chemistry*.

CHRYSOCOLLA. *Silicate of Copper.* Imported into Liverpool in large quantities from Mexico. A light bluish green in colour, hardness 4·0. Analysis by Mr. W. M. Hutchings:—

	per cent.
Silica *soluble* in Na^2CO^3	62·42
Silica *insoluble*	3·83
Oxide of copper	25·69
„ lead	0·12
„ zinc	0·34
Lime	0·74
Magnesia	1·06
Water	6·13
	100·50

With traces of cobalt and manganese.

Chemical News, September 29, 1876.

A similar mineral occurs on a gneiss in South Africa, as a blue layer in botryoidal forms, carrying here and there a green incrustation. Professor Maskelyne and Mr. Flight think this is chrysocolla mixed with two minerals, one a cupric arsenophosphate, the other belonging to the trochantite group.—*Journal of Chemical Society*, vol. x.

Bermann communicated to Professor Dana that he has specimens of chrysocolla from Chili which have in the interior the fibrous structure and the composition of pure malachite, showing that the whole was once that mineral.

Becquerel observes that silicate of copper may be formed through the action of a lime or magnesia silicate on sulphate or nitrate of copper.

CHRYSOPHANIC ACID.—This acid occurs in the roots of various rhubarbs and docks, and in the lichen *Parmelia parietina*, and in senna leaves.

Warren de La Rue's method of extraction is the most simple. He extracts rhubarb with benzol, distils off the benzol, and, when most of it has gone over, allows the residue to cool. Impure chrysophanic acid crystallises out. This is redissolved in boiling alcohol, filtered, crystallised on cooling, and purified by solution in glacial acetic acid.

Chrysophanic acid either forms gold-coloured crystals or orange-red masses of a golden lustre, like crystalline iodide of lead. From benzol it crystallises in hexagonal monoclinic tables of a yellow or orange colour; from glacial acetic acid, alcohol, and fused oil, it is deposited in mossy aggregations.

The formula ascribed by Graebe and Liebermann is $C^{14}H^{10}O^{4}$, and they regarded it as an isomer of alizarin.

This acid has been known at different times as rhein, rhubarb yellow, phaeoretin, erythroretin, rhaponticin, rumicin, lapathin, parietin, and other names.

CHRYSOTOLUODINE.—One of the aniline colours, dyeing wool and silk of a yellowish orange. It is obtained by dissolving mauveine in hydrochloric acid and adding tin to the liquid. When all is dissolved common salt is added, by which a yellow matter is thrown down resembling chromate of lead. This matter, collected, drained, and pressed, is exhausted with alcohol, in order to separate the colour from the compound of tin.—*Handbook of Dyeing and Calico Printing*, by W. Crookes, F.R.S.

CINNABAR. (Vol. i. p. 805.) A specimen of cinnabar, obtained near Canyon City, Oregon, when powdered and treated with dilute hydrochloric acid, gave off sulphuretted hydrogen. This induced Mr. C. W. Dabney, of Hampden Sydney College, Virginia, to examine it.

A specimen, freed from the lime by weak acetic acid, was dried, weighed, and acted on with hydrochloric acid of 6 per cent. real acid. The sulphuretted hydrogen given off was collected as sulphide of silver and the quantity determined. The residue was then analysed by the ordinary methods, adding in the small quantity of iron which the hydrochloric acid had taken up. The results were:—

Mercury	78·42
Sulphur	14·13
Iron	4·09
Silica	3·06
Oxygen (by difference)	0·30
	100·00

We may conclude that the iron existed as ordinary, and as magnetic, pyrites. By a careful redistribution of these constituents, the analysis stands:—

HgS	90·97
Fe^7S^8	1·37
FeS^2	1·95
Fe^2O^3	3·36
SiO^2	3·06
	100·71

These results serve to explain the abnormal proportions of sulphur and mercury in the published analyses of cinnabar, the iron having always been reported present as ferric oxide. In the analyses given by Dana and Rammelsberg we have—

No.	Locality	Analyst	For 200 parts Hg we have of S
1	Neumarkt	Klaproth	33·52
2	Japan	"	34·00
3	"	John	44·04
4	Westphalia	Schnabel	31·50
5	Wetzlar	"	44·42
6	California	Bealey	32·82
7	Idria (Hepatic)	Klaproth	33·62

instead of 32·0 as theory requires. In the third and fifth Mr. Dennis remarks native sulphur was probably present.

CLAY, PORCELAIN, Chinese. The samples investigated by W. Kuhlmann (*Dingl. polyt. J.* ccxx. p. 445) were from Kinkiang in China, in the form of bricks.

Analysis showed that 100 parts of the porcelain clay dried at 110° C

	1st Quality	2nd Quality	3rd Quality
Silicic acid (*soluble*) . . .	0·504	52·209	51·210
Silicic acid (*insoluble*) .	50·133	...	...
Alumina	32·737	31·997	33·150
Ferric oxide	0·955	0·712	0·709
Ferrous oxide . . .	1·690	1·911	1·986
Manganous oxide . . .	0·827	0·540	0·843
Lime	0·501	0·464	0·456
Magnesia . . .	0·268	0·278	0·284
Potash	2·520	1·560	1·403
Soda	traces	0·970	0·092
Loss	10·011	9·439	9·500

From these analyses it is seen that the clays used by the Chinese potter are very pure.

British.—The production of porcelain, potters', and fire clays, in this country during the years 1874 and 1875 was as follows:—

	1874		1875	
	Quantities	Value	Quantities	Value
Cornwall and Devonshire:—	tons	£	tons	£
Porcelain clay and stone . .	226,309	212,165	179,740	154,812
Devonshire } *Potters' clay* .	59,789	20,804	119,376	53,719
Cornwall } *Potters' clay* .	1,818	1,330		
Dorsetshire:—Poole clay . .	79,203	19,800	65,985	16,750
Fire clays of *Coal Measures*, United Kingdom . . .	2,067,791	516,950	2,643,353	528,676
Total value of clays . .		750,159	3,095,444	753,957

Our *Exports* of clays and clay manufactures were as follows:—

	Unmanufactured		Manufactured	
	tons	Value	cwts.	Value
In 1873 .	115,093 .	£140,036 .	. 3,042,734 .	£305,144
In 1874 .	116,815 .	142,004 .	. 3,042,697 .	230,907
In 1875 .	126,927 .	141,095 .	. 3,218,514 .	212,718

CLOANTHITE or **WHITE NICKEL.** A compound of nickel and arsenic. See Nickel.

COAL. (Vol. I. p. 816.) In 1873 the number of collieries in the United Kingdom was given as 3,061; since that period several new collieries have been opened, but during the past year (1876) some have been closed. For 1875 the Inspectors gave the number as 4,000, but this does not fairly represent those actually at work, as some of the inspectors have introduced the system of giving the number of *pits*, instead of the actual collieries. The returns for 1876, as given by the Inspectors of Collieries, show that the number of collieries may be assumed to be about 4,000, and the production of coal 134,125,166 tons.

Our *Exports* of coal and coke for 1874 and 1875 are given in detail in the following table. For 1876 it is not yet possible to give similar details, but the annual statement of the Board of Trade gives the total exportation of our fossil fuel.

Summary of the Coal Produce of the United Kingdom, computed from returns received by the Mining Record Office for the years 1873, 1874 *and* 1875 :—

Counties, &c.	1873	1874	1875
North Durham and Northumberland .	12,204,340	12,045,560	12,640,789
South Durham	17,430,045	17,000,260	19,456,534
Cumberland and Westmoreland .	1,749,030	1,103,407	1,226,737
Cheshire	1,150,600	615,105	658,045
Lancashire, North and East . .	9,600,000	6,095,570	8,824,798
Lancashire, West	7,500,000	7,442,950	8,250,240
Yorkshire	15,311,778	14,812,515	15,425,278
Derbyshire . . . . }	11,648,000	7,150,570	7,001,325
Nottinghamshire . . . }		3,127,750	3,250,000
Warwickshire . . . . }		851,500	799,760
Leicestershire . . . . }		1,100,465	1,151,019
Staffordshire, South, and Worcestershire	9,463,559	8,869,343	10,251,791
Staffordshire, North . . .	3,892,019	4,313,096	4,466,213
Shropshire	1,670,000	1,187,950	1,220,785
Gloucestershire . . . . }	1,858,740	1,147,272	1,273,060
Somersetshire . . . . }		609,684	654,878
Monmouthshire	4,500,000	5,038,820	3,625,075
North Wales	2,450,000	2,425,300	2,337,308
South Wales	9,841,523	10,184,885	10,682,597
Scotland, East	10,142,039	10,189,320	11,419,619
Scotland, West	6,715,733	6,608,835	7,177,855
Ireland	103,435	139,213	127,050
Total of the United Kingdom .	127,016,747	125,067,916	131,867,105

Coal and Coke Exports.

Countries receiving the principal Exports in the years 1874 *and* 1875 :—

1874.

Countries to which exported	Quantities exported		Declared Value	
	Coal	Coke	Coal	Coke
	tons	tons	£	£
Russia : Northern Ports . .	689,281	20,938	591,248	27,168
" Southern Ports . .	173,001	215	153,195	253
Sweden	577,537	22,733	438,423	29,051
Norway	306,736	12,547	232,490	16,587
Denmark	657,933	4,346	517,336	5,062
Germany	2,026,296	30,585	1,569,855	36,710
Heligoland	232	...	121	...
Holland	444,920	2,289	352,075	2,722
Belgium	229,125	70	176,109	103
Channel Islands . . .	62,345	54	64,114	85
France	2,270,180	2,220	1,794,949	2,467
Portugal, Azores, and Madeira .	227,170	1,929	206,041	2,914
Spain and Canaries . . .	476,041	68,273	453,051	90,824
Gibraltar	139,016	56	123,405	97
Italy	890,300	12,964	755,587	16,933
Austrian Territories . . .	82,968	1,421	71,478	1,741
Malta	312,135	50	296,315	65
Greece	65,612	13,694	60,545	15,693
Turkey	298,869	480	267,331	570
Wallachia and Moldavia . .	22,042	470	18,555	495
Egypt	617,578	...	576,161	...
Tripoli and Tunis . . .	2,349	...	2,099	...

Countries to which exported	Quantities exported		Declared Value	
	Coal	Coke	Coal	Coke
	tons	tons	£	£
Algeria	27,742	...	22,481	...
Morocco	...	...	...	...
Western Coast of Africa	76,930	...	79,512	...
Ascension	2,060	...	2,060	...
St. Helena	21	...	23	...
British Possessions in South Africa	44,141	112	42,983	359
Eastern Coast of Africa	11,868	...	11,731	...
Mauritius	16,502	112	14,358	308
Arabia: Aden	145,919	...	139,906	...
" Muscat	1,500	...	1,280	...
Persia	1,886	...	1,970	...
British India: Continental Territories	370,510	7,384	316,563	11,042
" Straits Settlements	200,630	21	192,630	45
" Ceylon	65,946	107	58,817	198
Java	46,162	677	41,536	1,239
Other Dutch Possessions in India	13,400	...	12,330	...
Philippine Islands	1,906	...	1,801	...
Siam	...	210	...	446
China and Hong Kong	64,630	597	54,261	1,512
Japan	7,966	233	7,251	645
Australia	14,728	1,008	13,772	2,163
Islands in the Pacific	247	...	101	...
British North America	165,849	904	137,531	1,115
United States of America:				
On the Atlantic	30,646	251	45,850	438
On the Pacific	71,610	292	55,606	608
British West Indies	133,171	226	106,417	447
Foreign West Indies	269,124	122	249,333	190
Mexico	2,152	...	2,039	...
Central America	1,718	...	1,652	...
United States of Columbia (New Granada)	5,470	...	4,554	...
Venezuela	970	1	917	1
Ecuador	645	...	962	...
Peru	122,790	1,134	116,291	1,254
Bolivia	2,919	313	2,049	466
Chili	201,073	9,686	159,119	12,560
Brazil	372,322	10,262	376,833	14,692
Uruguay	179,720	722	174,669	967
Argentine Republic	80,295	6,381	96,846	11,496
Falkland Islands	80	...	101	...
Total	13,381,071	336,240	11,359,458	314,246

1875.

Countries to which exported	Quantities exported		Declared Value	
	Coal	Coke	Coal	Coke
	tons	tons	£	£
Russia: Northern Ports	660,682	43,209	450,026	40,330
" Southern Ports	190,891	415	132,330	430
Sweden	715,012	25,782	483,080	24,713
Norway	375,104	20,131	221,302	20,130
Denmark	713,619	5,760	451,081	5,356

Countries to which exported	Quantities exported		Declared Value	
	Coal	Coke	Coal	Coke
	tons	tons	£	£
Germany	2,130,328	52,991	1,242,141	30,457
Holland	430,175	3,844	299,176	3,652
Belgium	223,646	1,036	193,221	1,035
Channel Islands	71,071	66	51,114	74
France	2,606,716	4,142	1,540,090	3,765
Portugal, Azores, and Madeira	261,098	3,345	182,766	3,220
Spain and Canaries	535,551	93,054	407,502	90,237
Gibraltar	147,900	...	111,025	...
Italy	972,091	14,577	618,349	14,695
Austrian Territories	71,766	1,731	40,774	1,571
Malta	231,873	100	172,397	282
Greece	63,666	18,078	50,046	16,763
Turkey	240,718	498	170,202	475
Wallachia and Moldavia	25,023	...	16,729	...
Egypt	527,250	2,996	396,963	2,676
Tripoli and Tunis	2,863	...	2,194	...
Algeria	25,435	...	15,846	...
Morocco	260	...	232	...
Western Coast of Africa	55,226	...	43,594	...
Ascension	3,457	...	2,536	...
St. Helena	1,602	...	1,214	...
British Possessions in South Africa	47,684	167	36,934	177
Eastern Coast of Africa	11,367	12	9,310	25
Abyssinia	1,033	...	1,250	...
Madagascar	460	...	315	...
Mauritius	25,164	129	18,250	159
Aden	74,797	...	59,115	...
Persia	2,355	...	2,496	...
British India: Continental Territories	366,866	7,942	266,707	8,676
" Straits Settlements	164,023	...	113,600	...
" Ceylon	74,083	245	64,550	409
Java	71,803	1,277	53,587	1,542
Other Dutch Possessions in India	12,375	...	9,603	...
Philippine Islands	10,301	...	7,364	...
Siam	841	...	692	...
China and Hong Kong	58,393	1,505	46,484	2,867
Japan	12,118	431	10,257	470
Australia	11,304	1,159	8,732	1,004
British North America	140,760	1,327	79,136	1,299
Islands in the Pacific (except Fiji)	150	...	153	...
United States of America:				
On the Atlantic	44,091	1,149	49,628	862
On the Pacific	46,002	1,064	29,751	1,136
British West Indies	162,971	153	102,468	160
Foreign West Indies	304,646	325	214,543	261
Mexico	4,760	...	4,633	...
Central America	320	...	362	...
United States of Colombia	4,194	...	2,033	...
Venezuela	419	...	301	...
Ecuador	98	...	104	...
Peru	114,030	1,728	89,767	1,773
Bolivia	4,068	30	2,304	28
Chili	223,654	7,051	146,715	6,989
Brazil	351,726	8,632	251,742	8,604
Uruguay	116,850	564	93,427	664
Argentine Republic	49,926	350	40,402	429
Falkland Islands	330	...	398	...
Total	13,975,956	307,629	9,155,861	298,606

Coal, Coke, Cinders, and Fuel (manufactured) exported in 1876.

		Value
	tons	£
To Russia	1,182,381	604,369
„ Sweden and Norway	1,156,885	643,440
„ Denmark	777,207	406,438
„ Germany	2,271,901	1,120,856
„ Holland	478,993	272,020
„ France	3,250,609	1,605,771
„ Spain and Canaries	762,031	461,494
„ Italy	1,226,205	645,343
„ Turkey	294,214	164,859
„ Egypt	543,068	323,202
„ Brazil	327,081	217,664
„ Malta	298,858	178,468
„ British India	750,182	463,770
„ Other countries	2,946,538	1,703,783
	16,265,839	8,901,716
Coal, &c., shipped for the use of steamers engaged in the foreign trade	3,564,524	not given
Carried out of the Country	19,830,363	

Africa, South.—Of coal and iron South Africa may be considered to have its fair share. The coal formation in the sandstone of the high ground forms the watershed of the rivers Orange, Vaal, Limpopo, and Lugela, and other rivers flowing to the east and south-east coast.

This tract of country is known as the 'Hooghte Veldt,' and slopes gradually towards the west and north, but in the east is broken by the precipitous escarpment of the Drakens-Vergen, Stormbergen, &c., in the sides of which are to be seen outcrops of seams of coal. The coal of Stormbergen, which is situate in the Cape Colony, can only be considered of use for local consumption, as the seams are very small; but those of the Drakensbergen, in Natal, and the outcrops seen in the Transvaal, where the plateau is broken, going northwards by sources of tributaries to the Limpopo, and westward by those of the Vaal, the seams are much larger, occurring from 3 to 7 feet in thickness.

No local requirements exist at present for such an article as coal, nor is any port on the east coast made available by road, rail, or river for transport purposes to the coast. Consequently this field of coal has not yet received any attention, and is for the present lying unvalued and, comparatively speaking, unnoticed.

Iron ores exist in South Africa in abundance, but nowhere do they exist in greater abundance or purity than at a site about forty miles south of the 'Hooghte Veldt'—the coal formation just alluded to. At this point, which is in the valley of the Steelpoort river, which is a tributary of the Oliphants river, and this of the Limpopo, and situate in the territory of the Transvaal, within 150 miles of the coast at Delagoa Bay—an undefined extent of country. Certainly many square miles in extent consists of rock composed of pure magnetic iron ore, of such excellent quality that almost every stone that one finds is a natural magnet, and even the sand of the soil is composed of it, the particles adhering to the tires of the waggon wheels, as the traveller proceeds, in the most interesting fashion.

The Crown Agents for the Colonies, have now (May 1877) sent out a practical coal miner to examine and report on the South African coal deposits, and Mr. Dunn is employed by the Government of Cape Colony to make a geological survey of these coal-fields.

Algeria.—The Compagnie de Mokta el-Hadid raised from their mines in 1875 91,193 tons of coal, of which quantity they actually delivered to purchasers 80,448 tons. A similar quantity is stated to have been raised in 1876, but the exact returns have not been received in Paris. (April 1877.)

America, North. (Vol. i. p. 853.) *Nevada Carboniferous Coal.* The Pancake Mountain is a low range of hills situated in the valley about midway between the White Pine and Diamond ranges, and occupies throughout its length of thirty miles or more the basin or trough of a synclinal fold. The higher mountain ranges, both east and west, follow mainly the axes of mountain anticlinals, and exhibit only

Devonian, Silurian, and Azoic rocks. About midway between White Pine and Pancake, two or three mounds, which are identical, both lithologically and palæontologically, with the limestone of Treasure Hill, crop through the quaternary formation of the valley, and still further west are found dark bituminous shales, identical with those found along the east slope of Treasure Hill, and under the towns of Hamilton and Eberhardt. Some four miles still further west, and belonging to a much higher geological horizon, we find the coal formation.

The formation immediately inclosing the seams (of which there are said to be two) is mainly slate, though in places a light coloured rock, which the miners call soapstone, comes in contact with them. Impressions of leaves and plants are found in the slates, and a few specimens of sigillaria have been found on the surface in the vicinity. The sandstone formation, from which is quarried the fireproof lining used in the Eureka furnaces, overlies the coal formation.

The seam, where worked, is situated near the north end of Pancake Mountain, about 14 miles west of Hamilton, and 20 miles east of Eureka. The seam strikes north and south, and dips quite steeply (40°) to the west. In thickness it varies from 5 to 6 feet, but it is much broken and displaced; and in some places the coal appears to have been destroyed, and a kind of ash fills its place. Several experiments at coking on a small scale have been tried, and have resulted satisfactorily. The citizens of Eureka are discussing the feasibility of lighting their town with gas made from this coal.

Steam hoisting and pumping machinery has been erected on the mine during the past winter (1876), and the company evidently is in earnest in its determination to find coal in paying quantities, if it exists.

The mine is opened by two inclines on the seam, the deepest of which is down 240 feet.—A. J. Brown, *American Institute of Mining Engineers.*

Arkansas. (Vol. I. p. 854.)—Arkansas coal has recently been introduced into the St. Louis market, and possesses considerable interest. It is mined in Johnson County, about 100 miles from Little Rock, on the Arkansas river, and can be put down at St. Louis for about \$8 a ton. Up to the present time about 300 tons have been delivered here. A trial in one of the blast furnaces of Carondelet showed that it was too friable to withstand the weight of the burden. The coal appears at first glance to be an ordinary fat bituminous coal, with regular laminated structure, but a closer inspection shows it to be of semi-graphitic character. It exhibits none of the columnar structure of the semi-bituminous coals of Pennsylvania or Maryland, except when subjected to rough handling, when it breaks up readily into cubical fragments. The seam is 3½ to 4 feet thick, and has been traced over a territory of 1,500 to 2,000 acres. Though there is a slight dip, no disturbance seems to have taken place in the formations. Analyses of two different samples gave the following results:—

	I.	II.
Moisture	1·07	1·05
Volatile matters	8·27	9·00
Fixed carbon	84·81	83·24
Ash	5·85	5·81
	100·00	100·00
Sulphur	0·983	0·876
Specific gravity	1·359	1·316

Colour of ash, light brown.

Professor W. B. Potter, *American Institute of Mining Engineers.*

Californian Coal.—The San Benito *Advance* calls attention to the discovery of coal in Slack's Canyon, Monterey County. 'In the locality of the Red Rock coal mine its distinguishing signs are clearly apparent, and the prospect made opens to view the whole suite of strata common to the coal measures, viz. sandstone, bituminous shale, iron stone, pure clay, and impure limestone. The hard and black and brilliant stratified beds of coal, varying in thickness, banishes the idea of the formation being recent. We entered one tunnel which penetrates the hillside about 30 feet, and found ourselves in a stratum of unknown thickness. This tunnel is 8 feet high and 6 feet wide, and nothing above or below or on the sides is visible but the black diamond. Even the little black mounds produced by the burrowing rodents give unmistakeable signs of coal, and we are convinced of the existence of a coal field extensive, and sufficient to supply the wants of California for a century. The district is easy of access, and a road can be constructed at a trifling expense to connect with the railway depôt at Los Gatos, the point to which the Southern Pacific Railroad Company

is now extending the line from Goshen. The mine and depôt are twelve miles apart. Several tons of coal have already been hauled from the mine to Tulare Lake, where it has been used satisfactorily for steamboat purposes. At the expiration of a few months, when shipping facilities are perfected, the contents of this mine will supply the trade of San Joaquim and the principal railroad cities of the state.'

Coal discoveries are reported on a branch of the Corralitos Creek, Santa Cruz county.

A perpendicular shaft has been sunk 160 feet, and at 150 feet a level driven northward for 225 feet. All the excavations have been in a friable sand rock, occasionally being hard enough to require blasting. All the coal indications at this depôt were occasional patches of disturbed bituminous strata, showing that they were detached portions of the main seam.

In the hill on the south side of the creek, and about 40 feet above it, the croppings of a seam were discovered by Mr. William Strader. This seam has a dip to the south of an angle of 50°; it runs east and west, and is nearly 4 feet in thickness.

A shaft has been sunk on the incline for about 5 feet. From thin layers of perfect coal at the surface, with imperfect coal between, it has 'thickened up its perfect seams to near an inch in thickness, with but little imperfect coal between.'—*The Scientific Press*, quoted in Saward's *Coal Trade Journal*, New York, January 3, 1877.

American Coal Statistics.—The following information of the coal used in the coal-consuming districts of the United States is from Saward's Annual Return, which is compiled with much care, and may be regarded as a reliable authority:—

Richmond, Va.

For the year 1875	Tons of 2,240 lb.
Kanawha coal	100,000
Cumberland and anthracite	49,700
Chesterfield county coal	31,002
Henrico county coal	2,590
Carbonite and coke	10,303
Total business done	205,591

Buffalo, N. Y.

For the year 1875	Tons of 2,000 lb.
Bituminous by lake	32,767
" by canal	45,000
" by L. S. and M. S. railroad	350,000
Blossburg Semi-Bituminous, by rail	75,000
Anthracite, by canal	250,206
" by rail	500,900
Total receipts	1,252,973

This has increased from 227,318 tons in 1863.

Boston, Mass.

For the year 1875	Tons of 2,240 lb.
Bituminous, from Alexandria, Va.	97,697
Bituminous, from Georgetown, D. C.	20,987
Bituminous, from Baltimore, Md.	168,798
Anthracite, from Philadelphia	023,245
" " New York	900,271
Bituminous, from Great Britain	2,798
" " Nova Scotia	29,700
Total for the year	1,233,022

This has increased from 770,366 tons in 1865.

Chicago, Ill.

For the year 1875 Received by	Tons of 2,000 lb.
Lake (474,812 *anth.*)	748,706
Illinois and Michigan Canal	7,775
Chicago and North-western Railroad	5,501
Illinois Central Railroad	38,295
Chicago, Rock Island, and Pacific Railroad	31,893
Chicago, Burlington, and Quincy Railroad	6,821
Chicago and Alton Railroad	378,000
Chicago, Danville, and Vincennes Railroad	205,580
Lake Shore and Michigan Southern Railroad (*anth.*)	776
Pittsburgh, Fort Wayne, and Chicago Railroad	112,600
Pittsburgh, Chicago, and St. Louis Railroad	150,340
Baltimore and Ohio Railroad	57,900
Michigan Central Railroad (*anth.*)	3,266
Total	1,643,478

The business in 1852 amounted to but 46,233 tons; in 1862, 218,423 tons.

Cincinnati, Ohio.

For the year 1875	Tons of 2,000 lb.
Youghiogheny	909,000
Ohio River	171,039
Kanawha	110,065
Cannel	22,774
Anthracite	9,960
Muskingum Valley	12,450
Hocking Valley	25,440
Other receipts	25,070
Total for the year 1875	1,410,742

The business in 1853–54 amounted to but 326,320 tons.

St. Louis, Mo.

For the year 1875. Routes of transportation	Tons of 2,000 lb.
Belleville and Southern Illinois Railroad	350,756
Illinois and St. Louis Railroad.	204,624
Ohio and Mississippi Railroad.	160,467
St. Louis and South-eastern Railroad	178,282
St. Louis, Vandalia, Terre Haute, and Indiana Railroad	191,912
Indianapolis and St. Louis Railroad	12,776
Cairo and St. Louis Narrow-gauge	107,164
Chicago, Alton, and St. Louis Railroad	1,780
Toledo, Wabash, and Western	16,250
Rockford, Rock Island, and St. Louis Railroad	1,500
Iron Mountain and Southern Railroad	995
St. Louis county waggon receipts (estimated)	75,000
Ohio and Cumberland rivers (barges)	55,126
Lower Mississippi river	1,800
Illinois river	1,500
Pittsburgh gas coal	50,000
Other sources	1,500
Total for the year 1875	1,274,219
Total receipts for 1874	1,106,022
Total receipts for 1873	1,200,000

Pittsburgh, Pa.

The receipts at this city during 1875 were as below:—

BITUMINOUS COAL IN TONS OF 2,000 POUNDS.

Routes of transportation	
Allegheny Valley Railroad	271,000
Castle Shannon Railroad	97,323
Connellsville Railroad	325,000
Pennsylvania Railroad	331,843
Pittsburgh, Charleston, and Virginia Railroad	45,980
Pittsburgh, Cincinnati, and St. Louis Railroad	249,891
Saw Mill Run Railroad	90,047
West Penn Railroad	150,000
Monongahela Slackwater	2,046,967
Total	3,606,678

COKE IN TONS OF 2,000 POUNDS.

Connellsville Railroad	550,000
Pennsylvania Railroad	422,905
West Penn Railroad	45,000
Monongahela Slackwater	39,306
Total	1,056,211

The coal trade of this city in 1844 amounted to 194,200 tons.

San Francisco, Cal.

For the year 1875	Tons of 2,240 lb.
Australian	136,860
English	57,849
Vancouver Island	61,072
Anthracite	18,810
Cumberland	10,325
Mt. Diablo	142,809
Coos Bay	32,869
Bellingham Bay	10,445
Seattle	67,100
Rocky Mountain	58
Total for the year 1875	538,209

The receipts in 1860 were only 77,636 tons, of which 39,585 tons was Pennsylvania anthracite.

Providence, R. I.

	Tons of 2,240 lb. Foreign	Domestic
1871	13,000	504,096
1872	9,454	623,842
1873	3,232	634,112
1874	6,604	532,564
1875	663	602,947

New Orleans, La.

	Tons of 2,240 lb.
Receipts for five years, 1869 to 1875	1,752,272
Average for one year	275,317

The coal brought to this market is mainly that from Pittsburgh and vicinity.

Mobile, Ala.

Coal received at Mobile	Tons of 2,240 lb. 1873	1874	1875
Pennsylvania and English	5,060	3,850	4,176
Alabama	1,166	1,154	1,801

London, England.

	By sea	By canal	By rail	Total
1873	2,665,650	11,195	5,147,413	7,824,258
1874	2,727,719	6,992	4,689,785	7,424,490

Broad Top Coal Trade.

For the year 1875	Tons of 2,000 lb.
Semi-bituminous coal *via* Huntingdon and Broad Top Mountain Railroad of Pennsylvania	204,291
East Broad Top Railroad	53,567

Shipments from this region began in 1856; the tonnage for that year was 42,000. Largest business was in 1864, when the tonnage was 356,615.

Blossburg Coal Trade.

For the year 1875	Tons of 2,000 lb.
Semi-bituminous coal from Tioga, Lycoming, and Bradford counties, Pa.	1,122,920

Shipments from this region began in 1840; the shipments for that year were 4,235 tons; the largest business was in 1873, when 1,541,163 tons were shipped.

Clearfield Coal Trade.

For the year 1875	Tons of 2,000 lb.
Semi-bituminous coal from Clearfield and Centre counties, Pa., forwarded *via* Pennsylvania Railroad	915,673

This district was opened in 1862; the tonnage was small for the first eight years, aggregating but 696,377 tons, then kept at about 500,000 tons annually until last year, when the tonnage was greatly augmented, as is shown above.

Cumberland Coal Trade.

Semi-bituminous coal from Alleghany County, Md.

For the year 1875	Tons of 2,240 lb.
Forwarded by Baltimore and Ohio Railroad	1,261,257
Forwarded by Chesapeake and Ohio Canal	879,532
Forwarded by Pennsylvania Railroad	160,906
For local use	40,080
Total for the year	2,342,773

Shipments began in 1842 with 1,708 tons; the largest business done was in 1873, when 2,674,101 tons were produced.

Anthracite.

The product from the beginning has been stated at the following amounts:—

	Tons of 2,240 lb.
For the year 1820	365
1821 to 1830	533,194
1831 to 1840	6,940,270
1841 to 1850	21,693,160
1851 to 1860	63,981,897
1861 to 1870	114,510,161
For the 50 years above named	206,606,325
For the year 1871	15,198,063
" 1872	18,929,263
" 1873	19,585,173

	1875	1874
P. and R. R. R. Co.	4,794,504	5,562,649
Lykens Valley	531,760	460,442
Delaware and Hudson	3,026,255	2,430,101
D., L. and W. R. R.	2,939,648	2,142,533
Penna. Coal Co.	1,368,207	1,336,033
Penna. Canal	207,500	320,187
Lehigh Valley Railroad	3,302,042	4,179,472
Central Railroad	2,661,635	2,972,256
Penna. Railroad	124,327	114,500
	19,026,890	19,521,292

In addition to the above it is safe to presume that the local consumption by engines, workmen, and local enterprises is 3,000,000 tons annually.

The production of all kinds of coal in the United States in 1874 was, in round numbers	46,500,000	gross tons
Of this anthracite was	21,679,886	"
Leaving for bituminous and lignite	24,820,114	"
The anthracite in 1875 was	20,643,509	"
The bituminous coal (*estimated*)	25,000,000	"
Total production of 1875	45,643,509	"

The production of Pennsylvania being—	1874 tons	1875 tons
Pennsylvania anthracite	17,920,372	19,467,639
" bitumen	3,506,304	3,773,388
	21,426,676	23,238,027

The area of the coal-fields of the United States of America, according to the *Census* returns:—

	Square miles
New England basin	500
Pennsylvania anthracite	472
Appalachian basin:	
Pennsylvanian section	12,302
Maryland section	550
West Virginia section	16,000
Ohio section	10,000
East Kentucky section	8,983
Tennessee	5,100
Alabama	5,330

	Square miles		Square miles
Michigan basin	6,700	Iowa	19,000
Illinois basin:		Nebraska	3,000
Illinois section	36,800	Kansas	17,000
Indiana section	6,450	Arkansas	9,043
West Kentucky section	3,888	Virginia	185
Missouri basin	26,887	North Carolina	310
Texas basin	4,500		

The total coal area is 192,000 square miles.

The Coal Trade of the United States.—The tonnage for the year 1869 is given as per *Census* reports of each State, and the production for the year 1875 is on the authority of the *Coal Trade Journal*:—

	1869	1875
Pennsylvania—Anthracite	15,670,275 tons	22,011,627 tons
,, Bituminous	7,798,517 ,,	11,500,000 ,,
Illinois	2,624,163 ,,	3,500,000 ,,
Ohio	2,527,285 ,,	4,868,252 ,,
Maryland	1,819,824 ,,	2,342,773 ,,
Missouri	621,930 ,,	900,000 ,,
West Virginia	608,878 ,,	700,000 ,,
Indiana	437,870 ,,	958,000 ,,
Iowa	263,487 ,,	425,000 ,,
Kentucky	150,582 ,,	425,000 ,,
Tennessee	133,418 ,,	425,000 ,,
Virginia	61,803 ,,	80,000 ,,
Kansas	32,938 ,,	75,300 ,,
Oregon	— ,,	125,000 ,,
Michigan	21,150 ,,	30,000 ,,
California	— ,,	500,000 ,,
Rhode Island	14,000 ,,	14,000 ,,
Alabama	11,000 ,,	60,000 ,,
Nebraska	1,425 ,,	10,000 ,,
Wyoming	50,000 ,,	350,000 ,,
Washington	17,844 ,,	100,000 ,,
Utah	5,800 ,,	45,000 ,,
Colorado	4,500 ,,	250,000 ,,
Total	32,886,689 ,,	49,694,652 ,,

In the following return of the coal produce of the United States in 1874, by R. P. Rothwell, M.E., New York City, the production of coal in the United States, given in tons of 2,000 lb., is the most complete return which has been made:—

	Reports to office of *E. & M. Journal*	Additional quantities reported by correspondents	Total by States	Percentage of each State to the whole
PENNSYLVANIA.				
Anthracite:				
Wyoming region, 10,204,764 gr. tons	11,429,336			
Lehigh* ,, 4,712,290 ,,	5,277,753			
Schuylkill ,, 6,714,074 ,,	7,519,763			
Sullivan ,, 36,268 ,,	40,620			
21,667,386 ,,	24,267,471			
Bituminous:				
Coal	8,775,034			
Coke, 1,203,039 = 6–10 of original coal	2,005,110			
Additional reports and estimates by correspondents located in the various districts	—	1,500,00	36,547,615	·7202

	Reports in office of *E. & M. Journal*	Additional quantities reported by correspondents	Total by States	Percentage of each State to the whole
OHIO.				
Bituminous:				
Coal	524,192			
Coke, 1,457 tons = 6–10 of original coal	2,428			
Reported by Mr. ANDREW ROY .	3,641,825	—	4,168,445	·0821
MARYLAND.				
Bituminous 2,410,895 gr. tons	2,700,202	—	2,700,000	·0532
ILLINOIS.				
Bituminous	1,037,005			
Balance based on a careful report to the Legislature, by a correspondent	—	1,540,000	2,577,005	·0508
INDIANA.				
Bituminous	159,144			
Additional report by local authorities	—	750,000	909,144	·0179
MISSOURI.				
Bituminous:				
By local authorities . . .	—	800,000	800,000	·0158
WEST VIRGINIA.				
Bituminous	505,127			
Local consumption, estimated by correspondents	—	74,000	579,127	·0114
CALIFORNIA.				
Lignite:				
Reported by local authorities .	—	450,000	450,000	·0088
IOWA.				
Bituminous	155,135			
Reported by local authorities .	—	200,000	355,135	·0070
WYOMING.				
Lignite	340,000	—	340,000	·0067
TENNESSEE.				
Bituminous:				
Coal	81,498			
Coke, 18,306 tons = 6–10 of original coal	30,510			
Reported by local authorities . .	—	200,000	312,008	·0061
KENTUCKY.				
Bituminous:				
Reported by local authorities .	—	300,000	300,000	·0059
COLORADO.				
Lignite	22,020			
Reported by local authorities .	—	175,000	197,020	·0039
OREGON.				
Lignite:				
Reported by local authorities .	—	100,000	100,000	·0020
WASHINGTON.				
Lignite:				
Reported by local authorities .	—	80,000	80,000	·0016
VIRGINIA.				
Bituminous:				
Reported by local authorities .	—	75,000	75,000	·0015
KANSAS.				
Bituminous:				
Reported by local authorities .	47,381			
	—	2,000	49,381	·0009

	Reports to the office of E. & M. Journal.	Additional quantities reported by correspondents	Total by States	Percentage of each State to the whole
ALABAMA.				
Bituminous	47,384			
Reported by local authorities .	—	2,000	49,384	·0009
UTAH.				
Lignite	27,000			
Reported by local authorities .	—	3,000	30,000	·0006
MICHIGAN.				
Bituminous:				
Based on Census taken in 1874 .	—	13,000	13,000	·0002
Not otherwise reported:				
North Carolina, Georgia, Texas, Arkansas, &c., estimated . .	—	50,000	50,000	·0010
RHODE ISLAND.				
Anthracite, estimated . .	—	14,000	14,003	·0003
Total	44,381,175	6,366,000	50,747,175	1·000

The anthracite coal reports are made in tons of 2,240 lb., while the bituminous coal is reported in pounds, bushels of various capacity, tons of 2,000 lb., and tons of 2,240 lb. For the sake of comparison the whole is reduced to the standard net ton of 2,000 lb., which gives the following statement:—

	Net tons of 2,000 lb.	Gross tons of 2,240 lb.
Anthracite coal	24,281,471	21,670,980
Bituminous coal, including 2,500,000 tons used in the manufacture of coke . .	25,248,684	22,543,468
Lignite, or brown coal	1,216,020	1,086,020
Total production	50,747,175	45,300,980

Anthracite Coal Trade.—The following remarks are abstracted from an American journal devoted to the coal and iron trade, and are at this time of considerable interest:—

'The present annual capacity of the anthracite coal companies, with all their works running smoothly, without accidents by fire, freshets or strikes, is just about 26,000,000 tons. During the five years ending January 1, 1877, they mined a little over 98,000,000 tons, or an average of 19,718,000 tons yearly, each company having about an equal proportion of strikes and stoppages. From 1865 to 1875, in ten years, the consumption of coal for domestic purposes was doubled, without regard to its increased use in the manufacture of iron. There has been a falling off in the demand for this purpose of just about 1,500,000 tons a year for the past two years—not any more. Yet its introduction into so many more stores and grates during these two years has made the consumption as great as at any previous period. All this notwithstanding the depressed state of times which we have been passing through, due largely to the fact that coal is, and has been for a long time past, the cheapest article used in domestic economy. The average annual product during these five years has been as follows:—

	Tons
Delaware, Lackawanna and Western Railroad Company .	2,870,565
Delaware and Hudson Canal and Railroad Company . .	2,629,530
Lehigh Valley	3,051,862
Philadelphia and Reading	5,063,585
Pennsylvania Coal Company	1,162,091
New Jersey Central, Lehigh and Susquehanna, Shamokin and all others	5,138,981

The law of supply and demand will always adjust prices. An over-production of the 1,500,000 tons has caused a loss to the coal companies during the past year of fully equal to $1 per ton, or, say, $18,000,000, and an apparent loss to stock and bondholders in the six great companies of over $100,000,000 in the comparative value of the stocks and bonds now with that of one year ago. Nor is the apparent loss confined to these companies alone. The effect has been far-reaching, injuring thousands

of individuals and industrial pursuits, embracing mercantile, commercial, and moneyed institutions in a very large area of the eastern portion of our country, with no compensating good resulting to any comparable extent.

'From a pretty careful survey of the field, it is estimated that the present annual capacity for production without new outlays for shafts, roadways, cars, and motive power for the several companies is as follows, viz.:

	Tons
Delaware, Lackawanna and Western Company	4,000,000
Delaware and Hudson Company	4,000,000
Lehigh Valley Company and its shippers	4,000,000
New Jersey Central, Lehigh and Susquehanna, Shamokin, &c., all the lower districts	6,000,000
Philadelphia and Reading	6,000,000
Pennsylvania Coal Company	1,500,000
Total	25,500,000

'It would require immense exertions on the part of all these companies to reach these figures, and everything would have to run very smoothly to reach such a tonnage within a term of two years, although the companies may claim such a capacity. That there will be mined during the year ending January 1, 1878, between 19,000,000 and 20,000,000 tons, as the companies are now moving, there is not a doubt, and this is where the trouble is and the loss is to come from, and nobody is bettered by any loss to the mining and carrying companies in the long run. For when any member of the body suffers the rest of the body feels its bad effects on its general system. Not one ton over 18,500,000 tons of anthracite coal should be mined during the year ending January 1, 1878. No combination of prices should be entertained. The great law of supply and demand will regulate the price well enough; each company has a market local to itself for a large share of its product; the competition at other points would be healthy. After a careful revision of figures before cited, it appears that a just allotment of production to the companies would be as follows for this year:—

	Tons
Delaware, Lackawanna and Western Company	2,950,000
Delaware and Hudson Company	2,950,000
Lehigh Valley and its shippers	2,950,000
Philadelphia and Reading Company	4,500,000
Pennsylvania Coal Company	1,150,000
New Jersey Central, Lehigh and Susquehanna, Shamokin, and all others	4,000,000
Total	18,500,000'

The Iron Age.

The Vancouver Coal Company has worked the Nanaimo colliery for several years. In 1871 the output was from 100 to 200 tons per day. The total production in 1874 was 81,728 tons, valued at \$6·00 per ton. In 1875, 42,421 tons were shipped, and a balance of 13,037 remained on hand. The principal markets are Victoria and San Francisco, but small quantities are also shipped to Honolulu, Mazatlan, Alaska, &c.

Canada.—Bituminous coal is worked in several districts of Canada.

The Wellington mine is one of the most valuable. This mine is situated 2¼ miles north-west of Nanaimo and 3 miles west of Departure Bay. At the point a trench cut through the clay covering showed the seam to have a thickness of 9 ft. of coal, resting on a bed of light drab sandstone. At a distance of a quarter of a mile from this there is another exposure, where the coal is from 4 to 7 ft. thick. An analysis of the coal by Dr. Sterry Hunt gave, by slow coking:

Fixed carbon	56·50
Volatile matter	34·70
Ash	8·80

The coal does not coke well. Last year (1875) a new opening was made which promises to be valuable. The total sales in 1875 were 48,223 tons, with 2,318 tons on hand at the close of the year. The output for 1874 was 29,813 tons. Preparations are being made by which the output will shortly be increased from 150 to 250 tons per day. At the mine the coal sells for from 5 to 6 dollars per ton, and in San Francisco, which is the principal market, for 10 dollars per ton.

Nova Scotia.—The following table has been published as showing the progress of the coal industry in the coal-fields of this colony:—

1785 to 1790 produced	14,340	tons
1791 „ 1800 „	51,048	„
1801 „ 1810 „	70,452	„
1811 „ 1820 „	91,537	„
1821 „ 1830 „	140,520	„
1831 „ 1840 „	339,981	„
1841 „ 1850 „	1,533,709	„
1851 „ 1860 „	2,599,829	„
1861 „ 1870 „	4,927,339	„
1871 „ 1876 „	3,793,730	„

If these returns are correctly given, there has evidently been a falling off in the quantity of coal raised in the year 1876, as is shown by the following official return for the year ending December 31:—

	Collieries. Tons
Cumberland County:	
Cumberland	5,056
Scotia	1,285
South Joggins	14,296
Spring Hill	72,596
Colchester County:	
Folly Mountain	12
Pictou County:	
Acadia	60,280
Albion Deep	44,612
„ Main	91,661
Intercolonial	53,872
Nova Scotia	21,375
Vale	34,590
Cape Breton County:	
Block House	34,819
Caledonia	30,789
Collins	7,693
Glace Bay	30,022
Gowrie	29,275
Ingraham	40
International	24,111
Lingan	15,289
Ontario	11,096
South Head	653
Sydney Mines	102,644
Victoria	17,672
Inverness County:	
Port Hood	2,549
Victoria County:	
New Campbellton	3,362
Total	709,646

Australia, South.—Coal on the Kilcunda and Cape Patterson, South Australia, coal-fields. Reported by Mr. Cowan:—

'*Kilcunda.*—The Western Port Company hold leases of 1,196 acres of Crown land for coal-mining purposes. The leasehold is distant about 8 miles from a practicable shipping place at Griffith's Point. Mr. Latham, a member of the company, accompanied me in my several visits to the workings, and gave me every assistance in his power. From the seashore, on which the leasehold abuts, an adit or tunnel runs into the hill 470 ft., and at that distance is about 45 ft. from the surface. From a space to the south-west of the adit, and from the adit itself, coal has been removed to the

extent of 56,000 superficial feet. An air shaft near the end of the adit ventilates the workings. In driving the tunnel, or adit, from the outcrop inland a fault was met with which throws the coal upwards a distance of 8 ft. At a further distance of 74 ft. another fault was met with which throws the seam downwards; but the depth of the downthrow was not ascertained from this part of the workings. Coal has been found in a 90-ft. shaft, about 50 ft. from the part at which the fault was met with in the adit, in a direction north 33° west. The coal in this 90-ft. shaft, which is soft and brittle, measures 2 ft. 4 in. in the south side, and in the middle 1 ft. 8 in.; but it is so near the fault, and so much troubled, that its dimensions afford no indication of the general thickness of the seam. Neither can the general quality of the coal be deduced from the seam discovered in the shaft. Two small faults, or hitches, of but little importance (an upthrow and a downthrow), were met with at right angles to the first-mentioned fault, throwing the coal out about the width of itself. I could not trace these faults to a greater distance than about 30 yards, at which point they seem to die out.

'In driving northerly from the mouth of the tunnel an upthrow was met with; but by continuing the drive along a level course intersecting the strata the coal was again cut at a distance of about 50 ft. from the last-mentioned point.

'In the continuation of this drive another fault was met with, displacing the coal downwards, but to what extent has not been ascertained, as it is not sufficiently penetrated; and indeed it would have been very unskilful and unworkmanlike to attempt to prove its extent at this particular point, as the dip of the strata is in the same direction as that of the fault. Neither is it certain that this is not, instead of being a fault, a reappearance of a dyke which is to be seen on the beach near to the mouth of the tunnel. Between the faults the coal has a much harder roof than in other portions of the mine from which coal has been removed. There is also a better parting, the roof having a glassy and lustrous appearance where the coal has been detached. An improved roof like this, the coal being constant, would economise the working of the mine; the cost of timber would not be so great, and the miners would be enabled to work to greater advantage. The dip of the coal here is 6° 22', and its course is north 57° east.

'*Cape Patterson.*—I paid two visits to the Cape Patterson field, but my examination of the coal seams there was exceedingly unsatisfactory. One important seam, said to be 3 ft. in thickness, could be seen only at low water. The seam being close to the coast, and dipping seaward, shows that it is of no commercial value. However, I discovered three small seams of 3 or 4 in. each cropping out below high-water mark, at short distances apart, and parallel to each other. These I concluded to be distinct seams, for to suppose otherwise there would require to be two faults, the projecting portions being worn off by the ordinary process of denudation.

'Mr. Davies informed me that a shaft 90 ft. deep had been sunk here, in which two seams of coal were found, one at 57 ft. of 2 ft. 10 in. of good clean coal, and another at 90 ft. of 2 ft. 6 in. These also must be distinct seams, unless it can be imagined that the deposit diverged from its course. This shaft I was desirous to examine, and Mr. Latham sent some men to clear it out, but they were unable to do so, and I could not fulfil my intention. If Mr. Davies' statements are correct, coal deposits may be expected here that could be profitably worked, even when due allowance is made for the circumstance that the inclination of the seam is inland. Seams of 2 ft. 10 in. and 2 ft. 6 in. being quite thick enough to be profitably worked, I endeavoured to find out why these had not been worked, and the explanation I received was, that the difficulties attending the shipping of the coal would have rendered the work unremunerative. No doubt the shipment of the coal would have been attended with considerable difficulty, but it may also have been that the faulty character of the country had its share in preventing the prosecution of the enterprise. Another obstacle to the profitable working of this ground is the presence of dykes, which, if tapped inland, might partially flood the mine and prevent its being worked so advantageously as it otherwise would be.

'I do not think that the coal found at Cape Patterson can be the same as that found at Kilcunda, for at the former place the dip is mostly seaward, while at the latter it is mostly inland, and if they were the same there would require to be either one continuous ridge from the one place to the other, the rocks dipping in opposite directions, or several communicating.'—*Report by* Thomas Cowan *to* A. Brough Smyth, *Secretary for Mines.*

A discovery of coal has been made in the Port Lincoln district, South Australia (February 1877).

Gippsland.—The known outcrops of coal seams, deserving to be so called, within the area mapped are six in number. The Strzelecki seam, the Stockyard Creek seam, the Hinton's Creek seam of bituminous shale, the Hazelwood seam, Ryan's seam, and

O'Mahoney's seam. Besides these, there are insignificant seams at Townsend Bluff, Anderson's Inlet, in the northern branches of the Tarwin, Stony Creek, near Yarram, and other localities.

The outcrop of the Strzelecki seam is in the bed of a creek tributary to the Tarwin, near the divide between that river and the Powlett, and about 14 miles north from the mouth of Screw Creek at Anderson's Inlet. The section exposed in the creek bank is—surface soil, clay, and rotten greyish-blue shale, 4 ft.; coal, 8 in.; soft earthy shale, 11 in.; coal, 2 ft. 9 in.; coaly shale, 3 in.; on shales and sandstones, with a slight apparent dip north-westerly. A shaft sunk on the high alluvial bank, near the outcrop, was stated to have cut the seam at 28 ft., and a bore close to the same spot is reported to have been carried down to a depth of between 200 and 300 ft., and to have passed through an aggregate of 10 ft. 6 in. of coal in various seams. In a branch gully, about 2 miles south, is another outcrop of coal, possibly the same seam, 1 ft. 6 in. thick, showing an apparent dip northerly. This was simply cut into, so as to expose it, and no other work has, we believe, been done in the locality.

The coal at the last-mentioned outcrop appeared to be of better quality than the large seam, though in both cases the coal was so deteriorated by atmospheric action that an opinion as to its quality would be hazardous; its appearance, however, indicated that it would be very good if obtained from an unexposed portion of the seam. From barometer readings this seam is about 750 ft. above sea level. Considerable difficulties would have to be surmounted before coal from this locality could be brought to market: 14 or 15 miles of tram- or railway would be necessary to connect it with Anderson's Inlet, the entrance to which is not available for vessels of large tonnage.

The Stockyard Creek Seam is in the creek bed, about 1½ miles above the township, and a few hundred yards from the boundary between the Silurian and Mesozoic rocks. This seam occurs in jointed grey sandstone, much intersected with calcareous veins, and dips rapidly to the north-west beneath the creek bed, occurring not in a regular layer, but in successive shelves from 10 in. to 22 in. thick.

The Rintoul Creek seam is in the bed of Rintoul Creek above 5 miles from Traralgon, and consists of a bituminous shale, burning readily but leaving a hard stony residue of bulk equal to what it was before burning.

The Hazelwood seam outcrops in the bed of a branch of Billy's Creek, a tributary of the Morwell, about 3½ miles SE. from the Hazelwood pre-emptive right, and 11 miles SSW. from Traralgon. This seam dips to the SE. at an angle of 27°; its floor is hard fine-grained sandstone, and its roof a thin band of soft shale, over which are hard shales and sandstones.

Suggestions for Prospecting for Coal Seams.—On commencing his labours in Gippsland, Mr. Reginald A. F. Murray was animated by strong hopes of discovering either new coal seams or geological indications confirmative of the expectations entertained by many that coal, in sufficient quantity at least for home consumption, would eventually be found. It must be confessed that these hopes have not been increased by the evidence of the facts observed, though it cannot yet be said that further endeavour to develop the coal resources is altogether hopeless.

Though the rocks in which our coal seams occur are not of the same age as those of the principal British and the New South Wales coal-fields, the mere geological age does not, it is maintained, materially affect the point at issue, as workable coal is said to be obtained in other parts of the world in rocks analogous to ours. Whether there are large coal seams or not in our mesozoic rocks depends on whether at the time of their deposition the requisite conditions for the formation of coal were present. That they were to a certain extent is proved by the seams which do exist, and of which, beyond their mere existence, we know so little.

None of the seams described are, as at present seen, remuneratively workable; whether they become so or not can only be ascertained by mining exploration. In considering what steps are advisable to discover whether workable coal exists in Gippsland, it may be well to offer a few remarks on the mesozoic rocks and their coal seams. 1st. The rocks are of great thickness, with a nearly uniform direction of dip south-easterly, and the edges of all the strata, with their intercalated coal seams, between the northern and southern margins of exposure, successively outcrop either at the surface or immediately below the tertiary deposits and surface soil. 2nd. Certain coal seams of good quality, but unworkable from their small size and high rate of inclination, are known to exist, but have been very insufficiently tested, and it is not known whether they are mere patches or seams extending over wide areas. At the outset it must be borne in mind that, if the usual high rate of dip continue, any workable coal seams discovered can only be worked for a limited distance in the direction of that dip, and that there is no evidence of a lower general angle of dip than 10°, or 1 in 6.

It is submitted that it is essential in the first place to acquire a thorough knowledge of the seams, by tracing their lines of outcrop along the hill sides from their points of exposure, by tunnelling into them at various points, and in some cases by sinking or boring to cut them. The known seams all show a tendency to thicken as traced down the direction of dip. It is desirable to ascertain whether this increase continues till they attain a workable size, as it is quite possible that they may have become attenuated near their outcrops, owing partly to the removal, by percolating water, of the disintegrated particles as decomposed.—*Report on the Geology and Mineral Resources of South-Western Australia.*

BELGIUM, Produce of coal in, in 1875:—

	Value in francs		Value in francs	
1st Arrondissement	3,890,120		63,521,000	
2nd "	3,842,700		57,877,000	
3rd "	3,235,355		51,883,435	
Total, Province of Hainault	———	10,968,175	———	173,281,085
4th Arrondissement, Province of Namur	—	491,365	—	5,931,101
5th Arrondissement	1,777,967		26,544,800	
6th "	1,702,724		23,105,310	
7th "	71,100		977,180	
Total, Province of Liége	———	3,551,791	———	50,627,990
Total of the kingdom, 1875		15,011,331 of		229,840,176

2,204 lb. 10 oz., or in English tons 14,743,271.

Exportation of Coal and Coke from Belgium in 1875.

	Coal	Coke	Total
	Tons of 2,204 lb.		
To France	3,680,254	307,390	4,328,395
" the Low Countries	130,990	4,025	136,749
" Zollverein (Prussia and the Grand Duchy)	41,171	334,363	518,682
" Chili and Brazil	1,365	"	1,365
" England	10	"	10
" Spain and Portugal	435	"	436
" other Countries	735	"	735
Total tons	4,080,960	645,787	4,986,512
Value in francs	81,279,200	18,082,036	99,361,236

FRANCE. *Production of Coal during the year* 1875.—This table has been constructed from statistics published by M. LE MINISTRE DES TRAVAUX PUBLICS in the *Journal Officiel* (May 24, 1876), from returns furnished by the Mining Engineers.

Products of Exploitation, distinguishing the three varieties.

Departments	ANTHRACITE. Metrical quintal 220 lb.	COAL. Metrical quintal 220 lb.	LIGNITE, 'STIPITE,' &c. Metrical quintal 220 lb.	TOTAL. Metrical quintal 220 lb.
Ain	...	...	8,866	8,865
Allier	128,170	10,301,791	...	10,429,961
Alpes (*Basses*)	...	236,650	190,450	427,100
Alpes (*Hautes*)	72,000	...	...	72,000
Ardèche	69,641	76,868	8,623	155,062
Aude	...	...	2,140	2,140
Aveyron	...	7,364,626	51,774	7,416,400
Bouches-du-Rhône	...	...	3,400,673	3,400,673
Calvados	...	122,022	...	122,022
Cantal	...	19,043	...	19,043
Corrèze	...	40,921	...	40,921
Côte-d'Or	86,850	...	...	86,850
Creuse	67,860	2,765,534	...	2,833,394

Departments	Anthracite. Metrical quintal 220 lb.	Coal. Metrical quintal 220 lb.	Lignite, 'Stipite,' &c. Metrical quintal 220 lb.	Total. Metrical quintal 220 lb.
Dordogne	...	...	10,515	10,515
Drôme	...	...	10,000	10,000
Gard	...	14,442,796	225,707	14,668,503
Hérault	112,783	2,572,487	15,364	2,700,634
Isère	1,050,470	...	21,000	1,071,470
Loire	42,102	32,765,310	...	32,807,412
Loire (*Haute*)	...	1,820,929	...	1,820,929
Loire-Inférieure	221,500	...	...	221,500
Lot	...	16,114	...	16,114
Maine-et-Loire	497,391	...	...	497,391
Mayenne	976,232	41,720	...	1,017,952
Nièvre	...	1,424,667	...	1,424,667
Nord	5,188,626	28,624,331	...	33,812,957
Pas-de-Calais	...	32,415,681	...	32,415,681
Puy-de-Dôme	192,462	2,240,955	...	2,433,417
Pyrénées (*Basses*)	1,050	...	...	1,050
Pyrénées (*Hautes*)	...	...	2,000	2,000
Rhône	...	307,002	...	307,002
Saône (*Haute*)	...	2,014,032	119,455	2,133,487
Saône-et-Loire	1,222,126	10,228,780	...	11,450,906
Sarthe	261,578	...	...	263,578
Savoie	257,511	...	...	257,511
Savoie (*Haute*)	1,560	...	43,165	44,725
Sèvres (*Deux*)	...	201,187	...	201,187
Tarn	...	2,402,800	...	2,402,800
Var	14,000	28,500	41,000	83,500
Vaucluse	...	...	68,530	68,530
Vendée	...	316,748	...	316,748
Vosges	...	...	25,010	25,010
	10,444,474	154,721,485	4,254,359	169,420,318

The metrical quintal is actually 100,000 grams = 1 cwt. 7 stone 11 lb. 6 grs.

The quantities of the different varieties of French coal, computed into English tons, raised in 1875 was

Of Anthracite	1,028,781	tons of 2,240 lb.
„ Coal	15,246,963	„ „
„ Lignite, &c.	418,354	„ „
Total production in 1875	16,693,798	„ „

India, *Coal in*.—Much energy has been displayed in developing the coal resources of India. At the Warrora mines, in the Central Provinces, a superior coal has been discovered, and the seams, the existence of which was known, have been ascertained to be more extensive than was anticipated. The supply of coal at these mines is estimated to be 40,000,000 tons, or sufficient at the rate of 500 tons a day to last for 260 years. The ordinary Warrora coal, when tested on the railway, showed a consumption of only 15 per cent. above that of English coal, similar results being obtained. With selected coal the inferiority would be diminished.

Italy. *Anthracite Coal.* (Vol. i. p. 347.)—A few lines only were devoted to the coals of Italy in the former volume, they were so unimportant. Chevalier W. P. Jervis, the Conservator of the Royal Italian Industrial Museum in Turin, has examined and published an account of the anthracite coal of Demonte, near Cuneo, in the Italian Alps. Of this coal formation he remarks—

'The anthracite coal of Demonte is highly worth while being worked; it is true coal of the carboniferous formation, and was originally bituminous coal such as is found in England.

'I have now no hesitation to pronounce boldly that the anthracitic coal of Demonte exists in considerable quantity, forming a zone of a certain breadth, which is in every respect worth being worked; and, in the second place, that this coal is by no means to be attributed, as has been hitherto maintained, to rocks belonging to the Mesozoic

period, contemporaneous with the oolitic group of England and France, in which case it would be nothing more nor less than a metamorphosed lignite, but that it belongs to the Palæozoic period, and is consequently far more ancient. I have, indeed, no doubt that it constitutes the base of the carboniferous formation, such as is found in Northern Europe, so that originally it was ordinary bituminous coal, like that of England, Belgium, Germany, &c., though, having been subsequently subjected to very slow and imperceptible, but powerful, chemical agencies, in common with every part of the majestic chain of the Alps, it has now lost almost all the volatile components, while the fixed carbon and the ashes remain behind in a concentrated form, so as to constitute a dry anthracite coal, producing in the process of combustion great heat, but giving out little flame, chiefly oxide of carbon, a powerful reducing agent so valuable for metallurgical operations. It is superfluous to dilate upon the importance of the distinction between lignites and true coal of the carboniferous formation, for while the former may exist, and be worked with the greatest advantage in a limited area, true coal alone is known to cover vast fields, and form large basins, such as would be quite within the range of possibility in the present case.

'The vertical distance between the beds of coal hitherto found varies between 23 ft. and 115 ft.—in other words, they are very near to each other, a circumstance facilitating their working. The rock intervening between the beds and on each wall is uniformly the same, consisting of argillaceous schists. The hanging wall, generally sufficiently solid and tenacious, rarely requires timbering. At the footwall one inch of fatty clay is frequently found, which would render the extraction of the coal an easy task. Faults are to be met with no doubt, as is common to other coal fields, but they produce a merely local strangulation of the beds, and will not prevent the levels from being driven through them. A peculiarity in the rock announces the vicinity of a fault, for there blackish clays occur, and groups of crystallised quartz in limpid prisms, with terminal planes, perfectly distinct from the massive quartz met with in the nodules described above in the midst of the schists. Generally, the beds of coal dip sufficiently to permit of the mineral being extracted with great facility, and thence lowered to the level where the railway will be placed for hauling it away. On the other hand, the inclination is not such as would prevent the filling of the part already worked maintaining its position. The topographical configuration of the ground being of a mountainous nature, with deep ravines, will render it superfluous for many a year to recur to pumps for draining the workings, and the small quantity of water which may be met with in this dry rock will all pass by means of a small lateral ditch through the adit level.

'An incalculable economic advantage will present itself to those who may work the mine of Monfiels—suffice to mention it in a few passing words. By means of horizontal galleries or levels, and without the necessity of sinking a single vertical shaft, it will be possible at a small cost to extract all the coal found in the upper part of the ravine over an area of 330 acres (150 hectares), and for a vertical height of at least 275 fms., without the necessity of a single vertical shaft for extraction or even ventilation. The ventilating winzes, owing to the peculiar configuration of the ground, will pass entirely through the beds themselves, as will the inclined planes for lowering the coal to the adit, whence it will be taken to the high road by inclined planes, or if worked on a small scale by aërial wires. Near the surface the coal of Demonte undergoes a considerable decomposition, becoming clayey, colouring in black the adjacent rock with which it is so intimately associated that in many instances it is quite impossible, without proceeding into the mountain by means of levels or borings, to ascertain the thickness of the beds.

'The anthracitic coal of Demonte is hard, of a fine lamellar structure, but has a property in common with all anthracite in being absolutely free from any trace of fibrous tissue or planes of cleavage and fracture, nor does it ever contain organic remains of any kind. A fine black dust is very frequently intercalated mechanically between the lamellæ, which are somewhat metallic in appearance. When taken in the hand it leaves a black stain, easily removed by washing in water without soap because it is not greasy. The specific gravity is very high, being 1·71, so that it is considerably more than lignite or common coal, the specific gravity of English coals being on an average 1·3, and that of Scotch coal often even lower. The high specific gravity must be attributed to the enormous pressure to which the coal has been subjected in the lofty mountain chain in which it is found, as well as to the greater proportion of ashes it contains, and the small quantity of volatile gaseous principles. In the samples submitted for examination and analysis scarcely a trace of sulphur was found, a considerable advantage, and which leads to the supposition that in the course of ages, in the act of losing the volatile combustible portions, the pyrites originally existing in it were converted into sulphate of iron, or green vitriol, which, being eminently soluble in water, has been washed out, and into peroxide of iron, which is

found in the ashes. Such chemical changes will certainly be traced down to the natural drainage level of the valley, to which the workings of the mine will certainly not reach for a considerable number of years.

'Two analyses of the anthracitic coal have been made at Turin at my request; the first, taken from the level at Mondicis, not far from the surface, gave—

Fixed carbon	76·00
Hygroscopic water	4·60
Combustible volatile matter	2·20
Ashes	17·00
Sulphur—not even a trace	...
	100·00

Lead reduced by an ounce of coal 24 ozs. Calorific units corresponding to the above result, 5704 (Berthier's method).

'Last February my colleague, Prof. Struever, was kind enough to make an analysis himself of a sample extracted a year later, and brought back by me from the mine last autumn. He found—

Fixed carbon	74·00
Hygroscopic water	6·20
Combustible volatile principles	1·30
Ashes	17·00
Sulphur—indeterminable traces	...
	100·00

Lead reduced by an ounce of coal 27·08 ozs. Calorific units corresponding to this result, 6233.'

Japan.—There are many coal-fields in Japan, but the principal are situated in the neighbourhood of Nagasaki, the best developed and most productive of all being in the small island of Takashima, about ten miles from Nagasaki. This is coal of old formation, and said to be nearly equal to English North-country coal, containing only about 5½ per cent. of ash, which is a very small proportion for a Japanese coal, as some of them contain as much as 20 per cent. of ash. The Takashima mine was first worked by the natives in the usual Japanese simple fashion, by adits only; consequently the mine was not very productive. In 1868 Messrs. Glover and Co., with the Prince of Hizen, obtained a lease of the property, sank a shaft 150 feet deep, and struck a seam 8 feet wide; and in 1869 the mine produced 35,000 tons of coal. These gentlemen did not hold the mine long; it was bought by the Government, and worked under its management, and in 1874 the same mine produced 72,428 tons. In the beginning of 1875 it was sold to a Japanese Company, and was producing 600 tons a day. Subsequently a fire occurred, which necessitated the flooding of the mine, and pumping machinery must be sent from England before work for coal can be resumed.

The following table is an estimate of the production of coal in Japan in 1874, and the probable extent of the respective coal-fields.

	Tons	Probable extent
Takashima	72,430	133 acres
Miike	66,224	10 (?) square miles.
Imabuku district	32,667	70 "
Taku	22,195	36 "
Karatsu	58,285	40 "
Hirado	63,160	120 "
Rest of Japan estimated at	74,939	
Total	390,000	

In the island of Koyaki there is one seam of good bituminous coal 5 feet thick, another 7 feet thick, and several smaller ones. These have at various times been worked by the Japanese. The Japanese never sink a shaft; they burrow where they suspect the existence of coal or ore, and having dug a hole, if mineral is found, the work continues, the seam is followed in the direction of its dip. But if the first trial be unsuccessful, another hole is dug, the first being abandoned; and no matter how many of these trial holes may be made, each separate hole is called a mine. The natives employ no more powerful means of raising water than bamboo pumps, and altogether their primitive method of working mines is so laborious and unproductive, that the mines are frequently abandoned after a short trial

The district of Karatsu furnishes a lignite of more recent formation than the Takashima coal, and although not nearly equal to the latter in quality, it is superior to that found on the main island; its large percentage of ash renders it useless except for household purposes.

At Shiramizu, north of Yedo, there is a coal field 30 miles long by 7½ miles wide; mines are situated a few miles from the coast, and there are no wheel roads. The cost of conveying the coal either by horse or coolie is so great, that the coal is allowed to accumulate during the summer, and only brought down in winter when it is required for household purposes, it being unfit either for steamers or for smelting; and as the Japanese generally use charcoal in their houses, there is but a small demand for this class of coal.

At Katsura there is a coal mine; the coal has a very good appearance, but refuses to burn unless mixed with other coal, when it does fairly well. A mine in the neighbourhood of Niigata furnishes a good coal, fit for the use of steamers, but the difficulty of getting it shipped prevents its being exported to any other market.

Analysis of some specimens of Japanese coal used in the Copper Refinery, and in the various metallurgical operations of the Mint, furnished by Mr. Gowland:—

Ash . . .	12·760	6·487	10·595	9·877	9·557
Sulphur . . .	·664	·435	·461	·558	·383

Patagonia *and Magellan Straits*.—G. de Sangainnecourt has discovered extensive deposits of coal, or rather lignite, on the coast of Patagonia (lat. 53° 9′ 40″, long. 73° 13′ 46″ W.). They extend over between 7 and 8 square miles. They consist of 3 beds, the thickest being about 16 feet.

Mr. Horace Rumbold, the British Minister at Santiago de Chile, has described the colony of Punta Arenas or Sandy Point, in the Straits of Magellan, as being the most southern civilised community on the globe. On this point coal exists, but as yet, although it is worked for the use of the colonists, much is not yet known.

New South Wales.—In the last edition (vol. i. p. 866) a list of the coal mines worked in 1869 was given, and a summary of the production of the collieries in 1872. We are now enabled to give in detail the production of coal in that year, and from *Mines and Mineral Statistics of New South Wales*, compiled by direction of the Hon. John Lucas, M.P., Minister for Mines, 'A Return of the Number of Coal Mines, and the Quantity and Value of Coal raised,' from the years 1864 to 1874 inclusive:—

Coal Production of New South Wales. 1872.

	Tons	Value £
Newcastle District.		
Bituminous Coal used for Steam, Household, Smelting, Gas, Blacksmiths', and Coking purposes.		
Australian Agricultural Company	184,272	66,226
Co-operative Colliery	97,402	48,331
Wallsend	165,000	62,100
Lambton	149,916	57,360
Waratah	170,334	62,315
New Lambton	100,944	48,353
Burwood (Redhead)	828	288
Total quantity and value	868,716	340,973
Splint and Cannel Coal.		
Stony Creek (cannel)	371	161
Anvil Creek (coal)	6,000	1,500
Four Mile Creek (coal)	17,661	2,788
	24,032	4,449
Rix's Creek and Wingen.		
Splint and Bituminous Coal.		
Mr. Elliott, Rix's Creek	714	393
Rev. J. Nash, Wingen	60	33
	774	426

	Quantity. Tons	Value. £
MURRURUNDI DISTRICT.		
Cannel coal for petroleum	300	600
SOUTHERN DISTRICT—*Illawarra.*		
Semi-bituminous Coal used for Steam, Household, Blacksmiths', and Smelting purposes.		
Osborne Wallsend Colliery	43,534	15,226
Mount Pleasant Colliery	43,232	15,131
Bulli Colliery	36,565	17,933
American Creek (used for oil making) . . .	350	320
JORDAN'S Crossing	200	160
	123,681	48,780
American Creek Petroleum Oil Shale made into oil at the works	2,740	4,100
WESTERN DISTRICT—*Lithgow Valley.*		
Splint Coal, suitable for House, Steam, &c.		
Eskbank Colliery (THOMAS BROWN, Esq.) . . .	4,321	1,300
Hermitage Colliery (Sir J. MARTIN and others) . .	800	240
Coerwull Mine (ANDREW BROWN, Esq.)	100	25
	5,221	1,565
NEW SOUTH WALES SHALE OIL COMPANY (cannel coal)	8,000	24,000

Produce of Coal Districts.

Coal Fields	Quantity		Value	
	1872	1871	1872	1871
	Tons	Tons	£	£
Newcastle District (bituminous) .	858,716	767,862	340,973	267,412
" (splint and cannel)	24,032	21,053	4,449	6,295
Newcastle District (splint and bituminous)	774	1,228	426	614
Murrurundi District (cannel) .	300	—	600	—
Southern District (cannel) . .	123,681	105,774	48,780	41,770
American Creek (oil shale) .	2,740	2,700	4,100	4,050
Western District (splint) . .	5,221	2,866	1,565	875
SHALE OIL COMPANY (cannel) .	8,000	12,000	24,000	30,000
	1,023,464	913,483	424,893	351,022
Produce in 1872 . . .	1,023,464	—	—	—
" in 1871 . . .	913,483	—	—	—
Increase in 1872 .	109,981	—	—	—
Value in 1872 .	—	—	424,893	—
" in 1871	—	—	351,022	—
Increase in 1872 . .	—	—	73,871	—

The production of coal from 1864 to 1874 is reported officially to have been as follows:—

Year	Number of Collieries	Quantity	Value		
		Tons	£	s.	d.
1864	25	549,012¼	270,171	11	0
1865	24	585,525¼	274,303	13	0
1866	25	774,238	324,049	6	7
1867	26	770,012½	342,655	7	8
1868	28	954,230¾	417,809	6	1
1869	33	919,773¾	346,146	16	5
1870	32	868,564¼	316,836	16	4
1871	27	898,784½	316,340	2	1
1872	26	1,012,426½	396,197	19	10
1873	29	1,192,861¾	606,746	17	3
1874	28	1,307,000	975,000	0	0

The area of the various coal-fields of New South Wales is approximately estimated at 24,840 square miles.

The amount of coal raised in 1874 in each coal-field was, in round numbers:—

The Northern Fields	1,120,000 tons.
" Southern "	137,000 "
" Western "	44,000 "

Analyses have been made for the Government in the colony; but the following is by Mr. Richard Smith, of the Royal School of Mines, London:—

Bulli Coal.

Carbon	75·67
Hydrogen	4·70
Oxygen and Nitrogen	4·99
Sulphur	0·51
Ash	13·17
Water	1·03
	100·00
Coke	74·78
Volatile gaseous matter	24·19
Water	1·03
	100·00

Sp. gravity = 1·471

Some analyses of the Wallerawang coal gave the following results:—

A sample from a seam 17 ft. 6 in. thick gave—

Moisture	1·51	
Volatile hydrocarbons	55·24	
Fixed carbon	33·74	65·24 per cent. coke.
Ash, white	9·50	
	99·99	

Sp. gravity = 1·333

Another seam 6 ft. 6 in. thick—

Moisture	1·95	
Volatile hydrocarbons	27·25	
Fixed carbon	61·86	70·80 per cent. coke.
Ash, white	8·94	
	100·00	

Sp. gravity = 1·398

Brown Coal is found on the Lachlan River, at the mouth of the Shoalhaven, at a

depth of 12 ft., also at Turalla Creek, county of *Argyle*, which retains the original structure of the wood, and has the appearance of box oak.—*Minerals of New South Wales*, by Professor ARCHIBALD LIVERSIDGE.

NEW ZEALAND, *Coals of Otago*.—Lignite of Pliocene age is found round the margins of nearly all the old lake basins. It no doubt exists in many other places in these basins, but so covered up by gravel as to be difficult to find. Lignites also occur in the older river valleys that existed before the time of the great river Pliocene depression. The lignites near Invercargill and at Orepuki may have been formed as estuarine deposits very slightly above the sea level, or they may have been formed by swamps when the land was considerably higher. These lignites vary very much in quality. Occasionally well-preserved trunks of trees are found in them, and generally their vegetable origin is easily recognised by the naked eye; but occasionally they pass into a compact brown mass, in which no structure is visible and which cannot be distinguished from brown coal. They often contain a fossil resin or *retinite*, which is a proof that they have been formed to a great extent by the decomposition of coniferous trees.

The thickness of these seams is often very great, amounting to 30 ft. in some places, but, like all lignite beds, they are local and unconnected.

The following are the analyses obtainable:—

	Totara Creek, Oamaru	Waitahuna	Tuapeka	Idaburn	Average
Water	13·40	11·06	16·50	11·60	13·75
Fixed carbon	39·10	37·28	34·40	16·07	36·92
Hydrocarbon	44·70	39·85	44·40	41·85	42·90
Ash	2·80	11·81	4·40	28·53	6·33

Brown Coal of Eocene age is found in Big Gully Creek in the Waitaki, where it was worked in 1861, and at Green Island and Saddle Hill; at Tokomairiro, Kaitangata, and Coal Point; at Orepuki, and at Taylor's Creek, Morely Creek, and the Nightcaps, in Southland. Thin seams of no value have also been found amongst the trachytes in Dunedin Harbour. The brown coal at Shag Point is of upper cretaceous age, while that of Preservation Inlet may be either Eocene or upper cretaceous, probably the former.

Bituminous Coal of Jurassic age is found in places from the Hokanui Hills to Catlin's River, and the same formation extends under a considerable part of plains between the Hokanuis and the sea. This includes an area of more than 1,000 square miles, but over the whole of it no seam thick enough to pay for working has as yet been found.

Shag Point Coal-field.—This coal was known and used in 1848, but the mine was first opened in 1863. The whole area occupied is about 26 sq. miles. Dr. VON HAAST has estimated that in the 70 acres surrounding Shag Point there are 'about 1,600,000 tons of coal, which, in order to allow for possible disturbances and other causes by which this quantity of coal might be diminished, reduced by one-third, would still leave us 1,000,000 tons of workable coal.' This coal is the best of the New Zealand brown coals; it contains little or no resin, and the following is the average of three analyses given by Dr. HECTOR:—

Water	16·57
Fixed carbon	43·16
Hydrocarbon	34·03
Ash	6·58

Green Island and Saddle Hill Coal-field.—This coal-field occupies the valley of the Kaikora stream, near Dunedin. It has a length of 5 miles, with a breadth of 2, and a superficial area of about 9 square miles. Besides smaller seams two good ones, varying from 6 ft. to 14 ft. in thickness, are known, and about 18 ft. may be taken as the average thickness of the known workable seams. It is calculated that 100,000,000 tons of coal are available in this field. Dr. HECTOR's analyses give us the average of five:—

Water	18·86
Fixed carbon	40·65
Hydrocarbon	36·57
Ash	3·92

Clutha and Tokomariro Coal-field.—This is the largest coal-field in New Zealand, having an area of about 90 square miles. The seams vary in thickness; the seam at Tokomariro Plain having 18 ft. of coal. On the left side of Tokomariro River two or three seams are known to exist which vary from 6 to 20 ft. in thickness. It is estimated that, after all deductions are made, 768,000,000 tons of available coal exist in this coal-field. Dr. Hector's analyses give—

Water	14·03
Fixed carbon	42·56
Hydrocarbon	36·93
Ash	6·04

Wairaki Coal-field.—This coal-field has an area of 27 square miles.

Orepuki Coal-field.—This field forms a triangle of about 3 miles in breadth and 1 in width.

Preservation Inlet Coal-field has an area of about 26 square miles—two or three good seams only exist.

Bituminous Shale is found near the head of Waitati Stream, behind Dunedin, giving 42 gallons of crude oil per ton.

PRUSSIA. *Production of Coal and Lignite.*—

COAL.

Districts	1873	1874	1875
	Centners of 100 metrical pounds = 110·231 lbs. Avoirdupois	Centners	Centners
Silesia, Upper	155,380,208	165,300,947	165,049,305
" Lower	45,896,385	47,019,876	48,837,973
Wettin	406,444	353,375	325,729
Löbejün	638,893	651,797	571,975
Hanover	6,317,377	6,573,493	6,748,896
Hubnstein, County of	501,095	372,256	269,773
Schaumburg	2,246,954	2,203,871	2,015,394
Minden	169,790	202,250	190,100
Ibbenbüren	4,611,339	4,538,424	4,433,474
Ruhr Basin (Westphalia)	322,641,924	305,038,677	335,972,566
Alx-la-Chapelle (Inde and Worm Basins)	21,037,039	20,095,408	19,509,690
Saarbrücken Basin	87,210,911	86,420,331	91,400,211
	646,958,183	638,773,665	668,385,989
Production in 1872	590,476,512	—	
Increase	56,482,671	—	29,612,324
Decrease	—	8,184,518	

LIGNITE.

	1873	1874	1875
	Centners	Centners	Centners
Brandenburg	25,500,039	29,768,767	30,269,950
Pomerania	13,752	2,122	—
Posen	264,221	266,352	258,462
Silesia	8,470,547	8,934,071	9,156,580
Saxony, Prussian	118,458,592	127,596,501	150,448,424
Hesse and Nassau	4,230,167	4,563,644	5,114,018
Hanover	93,928	106,780	90,010
Rhenish Provinces, including Wiesbaden in 1876	2,616,433	3,092,749	3,786,157
Total	159,756,649	174,332,986	166,805,152
Production in 1872	148,992,730		—
Increase	10,763,919	14,576,337	—
Decrease	—	—	7,527,801

Summary of Coal, Brown Coal, Asphalt, and Petroleum produced in PRUSSIA *from* 1871 *to* 1875.

	1871	1872	1873	1874	1875
	Centners	Centners	Centners	Centners	Centners
Coal . .	519,340,875	590,475,512	646,058,163	635,778,655	668,385,959
Brown coal .	137,524,902	148,992,730	150,756,649	174,382,986	166,805,182
Asphalt . .	—	—	34,600	476,304	410,000
Petroleum .	—	—	770	770	770
Total .	656,865,777	739,468,242	807,060,602	813,582,765	835,601,941

Zeitschrift für das Berg-Hütten u. Salinen-Wesen im Preussischen Staate, xxiv. *Band,* 5 *Lieferung.*

RUSSIA.—The best coal in Russia is found in the coal-fields of the Donetz Mountains. Good coal has, however, been found on the Ural Mountains. It is known to exist in the Governments of Toula and Riasnoe, also, not far from St. Petersburg in the Governments of Tver and Nowgorod. SEMOTUS KNAW of St. Petersburg analysed several samples. The following are the results as published in the *Chemical News.*

Nowgorod.—This coal is properly brown coal *lignite*, containing from 3 to 6 per cent. of sulphur.

1. Coal from River Prikcha, 30 miles north of the town of Borovitchi:—

Carbon	36·70	per cent.
Volatile matter	46·80	"
Ash	16·50	"
	100·00	"

According to BERTHIER's calorimeter this coal gave 4,500 calorific units. It contains 16·90 per cent. of hydroscopic water. The dried coal gave 62·18 per cent. for coke, and yielded 6,200 cubic feet of gas per ton.

Tried coke from this coal gave—

Carbon	78·03	per cent.
Volatile matter	10·71	"
Ash	11·26	"
	100·00	"

It gave 5,910 calorific units, and was found a good coke for the reverberatory furnace.

Toula.—This coal is found from 30 to 70 feet from the surface.

Obidimovo coal on the Riask-Viasma Railway, 15 miles from Toula, gave—

Carbon	36·14	per cent.
Volatile matter	45·65	"
Ash	18·21	"
	100·00	"

This coal resembles the Scotch Boghead coal. It gave 4,100 calorific units, 2·55 per cent. of hygroscopic water, and 3·23 per cent. of sulphur.

Riasnoe.—This coal is good for reverberatory furnaces and gas manufacture. Mouraevna Colliery. The coal from this place gave—

Carbon	17·60	per cent.
Volatile matter	66·26	"
Ash	8·61	"
Hygroscopic water	7·53	"
	100·00	"

Its heating power is 5,485 calorific units, and it contains 2·40 per cent. of sulphur.

Ural Mountains.—This coal has not been explored.
Vasilikour coal, which makes good coke, gave—

Carbon	77·86	per cent.
Volatile matter	12·30	"
Ash	2·72	"
Hygroscopic water	7·12	"
	100·00	"

Donetz Mountains.—This is the largest and best known of the Russian coal-fields. The anthracite which it yields is used for blast furnaces.

Grouschevka Mine, situated on the Rostov-Voronege Railway, yields a coal giving

Carbon	90·80	per cent.
Volatile matter	7·22	"
Ash	1·08	"
	100·00	"

7,040 calorific units.

Alexandrovka Village. This coal gave—

Carbon	69·92	per cent.
Volatile matter	29·00	"
Ash	1·08	"
	100·00	"

7,690 calorific units.

Uspenskoe Village, near the town of Backmouth, gives—

Carbon	64·85	per cent.
Volatile matter	28·90	"
Ash	6·25	"
	100·00	"

It contains 0·67 per cent. of sulphur, and shows 7,970 calorific units. It makes good coke.

Analyses of some samples of Russian coals by Sasatira Kraus, St. Petersburg, were given in the *Chemical News* (vol. xxxi. p. 133). A further description of some other samples examined by the same chemist may be of interest.

Government Tula.—1. Village Kiortai, on the river Oka, 3,000 calorific units; 3·07 per cent. of sulphur:—

Carbon	22·54	per cent.
Volatile matter	27·78	"
Ash	49·68	"
	100·00	"

2. Village Krasni Cholmi, 4,000 calorific units:—

Carbon	52·00	per cent.
Volatile matter	31·32	"
Ash	16·68	"
	100·00	"

Village Vislino, in the Ochinsky District, 4,000 calorific units; 2·15 per cent. of sulphur:—

Carbon	39·68	per cent.
Volatile matter	52·40	"
Ash	7·92	"
	100·00	"

4. Village Malevka, in the Bogoroditsk District, 3,500 calorific units; contains 32 per cent. of hygroscopic water:—

Carbon	34·88 per cent.	
Volatile matter	42·76	,,
Ash	22·36	,,
	100·00	,,

Government Kalouga.—5. Village Zelenino, 3,500 calorific units; absence of sulphur:—

Carbon	30·35 per cent.	
Volatile matter	48·36	,,
Ash	21·29	,,
	100·00	,,

6. Village Guameesky, in the Sikhoin District, 4,200 calorific units; fresh coal contains 30·06 of hygroscopic water:—

Carbon	35·70 per cent.	
Volatile matter	44·24	,,
Ash	20·06	,,
	100·00	,,

Government Ekaterinoslaw.—7. Near the village of Mr. Ilovaiski; calcined, leaves 71·70 per cent. of compact coke; 6,000 calorific units; sp. gr. 126; 10,600 cubic feet of gas per ton:—

Carbon	72·72 per cent.	
Volatile matter	24·47	,,
Ash	2·48	,,
Hygroscopic water	0·33	,,
	100·00	,,

Government Simbirsk.—8. Near the town Sysrane, on the river Volga, 5,600 calorific units; bad coal:—

Carbon	17·20 per cent.	
Volatile matter	37·30	,,
Earthy matter	28·40	,,
Hygroscopic water	17·10	,,
	100·00	,,

9. *Caucasus.*—On the rivers Coubane and Chummar the coal gives compact coke, 7,000 calorific units:—

Carbon	58·85 per cent.	
Volatile matter	37·99	,,
Ash	3·16	,,
	100·00	,,

10. *Donetz Mountains.*—On the river Bolshaia-Nesvitaia, good anthracite; 7,600 calorific units; 0·27 per cent. of sulphur:—

Carbon	93·27 per cent.	
Volatile matter	4·92	,,
Ash	1·81	,,
	100·00	,,

Chemical News, vol. xxxii. p. 79.

Coal of the World.—The following Table has been compiled from the most reliable sources, and it is believed to be a very close approximation to the truth:—

Coal Product of the Globe, in tons of 2,240 lb.

Countries	1873	1874	1875
Great Britain	127,016,747	125,067,916	131,867,105
United States	50,512,050	47,872,963	49,694,632
Germany	45,335,741	40,685,332	42,283,097
France	17,500,000	17,059,847	16,695,768
Belgium	15,771,401	14,669,029	15,011,331 [1]
Austria	10,369,953	11,000,000	10,895,000
Russia	1,123,940	1,343,658	1,750,000
Spain	587,707	600,000	560,000
Portugal	18,000	18,000	17,670
Nova Scotia	1,051,567	872,720	781,165
Australia	1,226,473	1,304,567 [2]	1,670,500
India	550,000	550,000	725,250
Japan	150,000	300,000	325,500
Vancouver's Island	75,000	80,000	97,644
Other Countries, New Zealand, Chili, China, etc.	1,000,000	1,250,000	1,375,500

The Production of Mineral Coal in the United Kingdom of Great Britain and Ireland from 1854 to 1876 is given as follows in the *Mineral Statistics*:—

Years	Gross tons	Years	Gross tons
1854	64,661,401	1866	101,630,544
1855	61,453,079	1867	104,500,480
1856	66,645,450	1868	103,141,157
1857	65,394,707	1869	107,427,557
1858	65,008,649	1870	110,431,192
1859	71,979,765	1871	117,352,028
1860	80,042,698	1872	123,497,316
1861	83,635,214	1873	127,016,747
1862	81,638,338	1874	125,043,257
1863	86,292,215	1875	131,867,105
1864	92,787,873	1876	134,125,166
1865	98,150,587		

For 1875 the colliery inspectors gave 133,306,485, or one million and a half, tons nearly, more than the returns made to the Mining Record Office. I believe this to arise entirely from the ill-judged rule of requiring the coal inspectors to give returns of the number of fatal accidents in proportion to the number of tons of coal raised in each district. There is a very natural tendency to place the quantity of coal raised at the highest value, as this reduces the per-centage of deaths relatively to the proportion of coal produced.

Coal Analysing.—The following mode of analysing coal for practical purposes deserves attention:—

If by heating a small portion of powdered coal with 5 grains of caustic potash for several minutes, the latter after cooling remains colourless, or becomes but slightly yellow, the coal belongs to the true old coal—'pit coal.' If the alkaline solution turns dark brown or becomes opaque, it is 'lignite.'

To detect Sulphur.—One grain of powdered coal is mixed with 4 grains of nitrate of potash and 2 grains of anhydrous carbonate of soda, and the mixture transferred, in small quantities, to a silver or platinum crucible of 30 grains' capacity, heated to low redness. Having introduced all the mixture, the lid is replaced, and the whole heated to a lively redness for a quarter of an hour. When cold, the contents of the crucible are treated with water, and the solution supersaturated with hydrochloric acid. To the solution chloride of barium is added, and the sulphur estimated from the sulphate of barytes obtained.

The determination of Water and Ash Constituents.—Ten grains of powdered coal are placed in a platinum crucible in an air-bath, and heated to about 120° for two hours, or until a plate of cold glass, held over the open tubulature of the bath, shows no film of moisture. The loss in weight is water. The heat is then continued until no volatile matter can be detected escaping. When cold the residue is weighed as ash.

[1] Tons of 2,204 lb. In English tons of 2,240 lb., 14,743,271.
[2] New South Wales only, for 1874.

Estimation of Carbon and Hydrogen.—Five grains of coal are dried at 150° C., and again weighed. They are then ignited with oxide of copper, and finally in a current of oxygen or with chromate of lead, and the carbon and hydrogen estimated from the CO^2 and H^2O obtained.

Estimation of Nitrogen.—One grain of powdered coal is ignited with soda lime, and the nitrogen evolved by ammonia absorbed by acids. Hydrochloric acid is the best absorbent, as we obtain then sal ammoniac, which, by evaporating the solution, can be very readily weighed.—G. C. WITTSTEIN, *Pharm. J. Trans.* vii.

COAL CUTTING. *The American Monitor Coal Cutter.*—The only coal-cutting machine in successful operation in the United States is the invention of HORACE F. BROWN, of Indianapolis, Indiana, and is the result of a series of experiments extending over a period of nearly four years.

This machine may be described as a square cast-iron frame revolving upon a lower frame, or bed plate, upon which the driving and feed parts are arranged with the greatest economy of space consistent with freedom of movement and accessibility, and a revolving cutter rim carrying the cutters and supported by a radial arm attached to the frame. The power is supplied by two trunk engines, driven by steam or compressed air carried from the mouth of the pit in iron pipes, which terminate with a sufficient length of rubber hose to allow of free motion to the machine.

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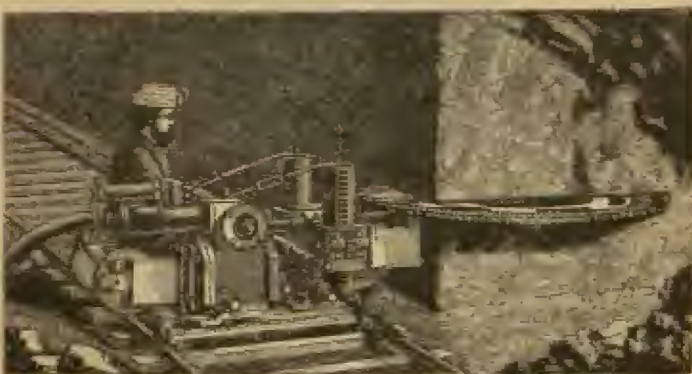

The details can be better understood by an examination of the drawings.

Fig. 2291 gives a perspective view of the machine in operation, and *fig.* 2292 a plan of the same. Similar letters indicate corresponding parts. The frame already referred to is shown by E; upon this rests the trunk engines, G G, 9 inches in cylinder diameter, and 8 inches in length of stroke. Through the medium of the main shaft and worm I, motion is communicated to the driving shaft H, carrying the pinion H''. by which the cutter rim is revolved.

The cutting arm is in two parts, the supporting arm and the cutter rim, and is a leading feature of the machine. The supporting arm, A, is a flat, open, malleable iron casting, bolted firmly to the bracket, C, by a flange-like projection, and, with the exception of this projection, is entirely inclosed within the cutter rim. Thus supported and steadied, and kept in place by a series of horizontal disk-like rollers, A', is the revolving cutter rim, B, 5 feet in diameter and $1\frac{1}{4}$ inch in thickness, and which receives motion from the driving shaft, H, by a circle of slotted perforations near its outer edge being engaged by the pinion. This device does away with a hub, and enables the cutter rim to penetrate the coal over seven-eighths of its diameter, or a depth of 56 inches, and the power being applied at the circumference or point of resistance, there can be no loss by leverage. Upon the periphery of this revolving rim are placed the cutter holders, B', shown with details in *figs.* 2293 and 2294. Each holder is armed with four cutting points, two acting when the rim revolves from left to right, and the others when it moves in the opposite direction. These points are merely two-inch lengths of $\frac{5}{8}$ by $\frac{3}{8}$ chrome steel, forged to an edge, and are held in place by blocks, grooved so as to give them the proper set. These blocks, as shown in *fig.* 2294, are fastened into the holders by screws, so that the operator can easily replace the points by others when they become dull. *Fig.* 2294 also

shows the order in which the cutter points are placed upon the cutter rim. It will be noticed that they are set at different angles, so that, although the action is continuous, the duty of each is only one-sixth of the kerf, and also that those points set at the greatest angle widen the cut sufficiently to clear the cutter arm from both the overhanging coal and the bench beneath. The bracket, C, carrying the cutter arm, is attached to the sleeves, D D, which are vertically adjustable, and held at any desired elevation on the columns or guides, D′ D′, by means of the hand-worked mitred gearing shown in *fig.* 2291. This enables the operator to raise or lower the cutter

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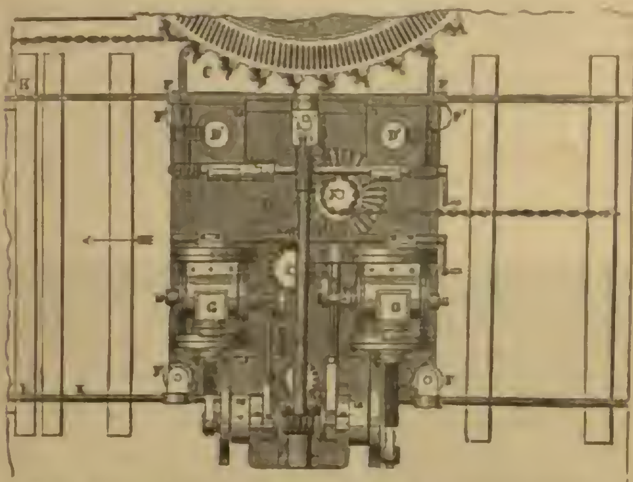

arm at will, and select, within a range of 3 feet 6 inches, the most favourable part of the seam for the cut. Either of these sleeves can be adjusted independently of the other, and the cutter arm thereby angled in such a manner that the machine can be worked in a seam dipping or rising rapidly, and also avoid any interlaminated rock or slate which may interrupt a straight cut. The driving shaft, H, being in sections, one of which is squared and 'telescopes' into a correspondingly squared sleeve upon the other, is capable of longitudinal adjustment, which, in connection with the universal joint, H′, enables it to accommodate itself to the variable elevation of the cutter arm.

By the shaft, I, and a system of intermediate gearing so compounded as to reduce the speed, the worm, I, is geared to the upright capstan, J′, around which the draft or

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feed chain passes; and to bring the draft as near as possible to the point of greatest resistance, this chain also passes over a roller under the bracket C, and then is carried along and made fast at the end of the wall, as seen in *fig.* 2292. This gives the machine an automatic feed to the right or to the left, or forward or back, according to the position of the fast end of the chain. The speed can be regulated to suit the hardness of the coal by reducing or enlarging the capstan. The feed-gearing shown in the drawings will move the machine at the rate of 9 inches per minute, the main shaft making 180, and the cutter rim 6 revolutions in the same time.

In a recent machine a hand-worked windlass was successfully substituted for the automatic feed, moving the machine through the coal at the rate of 1 foot, and in one instance 18 inches per minute, without increasing the engine speed or air pressure.

The machine runs upon an ordinary T-rail track of the same gauge as the mine system, so that the pit cars can follow and remove the coal. Each working face has its own track, which is moved up to the new face as soon as the coal loosened by the former cut is cleared away. When drawn over the mine-track system, the machine is provided with 15-inch flanged wheels, fitting upon spindles, r″, r″, r″, r″; but upon reaching the place of operations they are laid aside, and the machine is trundled upon a series of small rollers, r, r, r, r, with pivoted bearings, which allow of their being turned at right angles, so as to run upon either the wall track or the hereinafter described cross track. Similar rollers, r′, r′, r′, r′, placed horizontally and bearing against the inner sides of the rails, serve in lieu of flanges on the other rollers for keeping them upon the rails.

Preparatory to making a cut, the track, K, K, is placed parallel to the wall, adjusted by set screws in the ties, and braced, as far as possible, against neighbouring props; a cross track, K′, K′, intersecting and extending from it at right angles, connects with the mine track system. With the feed chain and cutter arm extending toward the coal to be attacked, the machine moves forward against the face, and the cutter arm channels its way into the coal, until upwards of seven-eighths of its diameter has penetrated the mass. By this time the machine has reached the intersection of the two tracks; the segmental plates, which thus far have formed a part of the cross track, are now turned so as to bring their straight sides on a line with the main track; the rollers r, r, r, r are also turned at right angles to their former position; the feed chain is carried along the track, and the machine, being again put in motion, moves along the wall to any desired distance, making a continuous 1½ inch cut to the depth of 56 inches. By the cutter holders being pivoted, the machine can be fed either to the right or to the left, the cutting points which are ahead being thrown up when the rim revolves. This feature, together with cutting its own starting place in the coal, gives the 'Monitor' great advantages over machines designed for making a similar undercut. When the limit of the wall track is reached, the feed is thrown out of gear without stopping the cutter rim, and by the hand-worked gearing, H″, the entire machine, with the exception of the lower frame, K′, which always remains parallel to the wall track, is slowly swung around, the cutters continuing their work, until the cut is sufficiently squared up to allow of the coal being wedged or blasted down even with the rib or pillar without recourse to the pick. A cross track, similar in all respects to the one already described, now receives the machine, and the flanged wheels being replaced, it is moved to the next face. In *fig.* 2201 the machine is represented as approaching the cross track. The curved rails, t, t, are laid down after the machine is removed, for the accommodation of the pit cars, which, when the latch switches, K‴, K‴, are open, can readily pass from one track to the other. The chippings, in the form of fine slack, are carried around with the cutters and deposited between the track and the wall, and the cut is kept so free that it has never been found necessary to resort to scrapers before taking down the coal.

Mr. John Alexander, who read a paper on the 'Monitor Coal Cutter' at the St. Louis meeting of the American Institute of Mining Engineers, says:—

'Machines built on this system have been in use since June 1873, in Messrs. Niblock, Zimmerman and Alexander's Coal Brook Mine, No. 3, near Brazil, Indiana, working in both the upper and lower block coal veins of that district. This coal, especially that of the lower vein, is very hard and dense, and, being of a stratified nature, is so difficult to mine, that wages rule higher in this field than in almost any other part of the United States. The work imposed upon the cutter in this mine has, therefore, been very severe, affording an opportunity of testing its capabilities very thoroughly. The item of wear and tear has been reduced to a very satisfactory point, and as most of the parts move slowly, and cast steel and malleable iron are used wherever the friction and strain are the greatest, little trouble is found from this source.'

The following additional particulars are given:—

Weight	3,400 lb.
Cylinders	9 in. diam., 8 in. stroke.
Extreme depth of cut	56 in.
Height, from rail to top of rocker-valve chest	23 in.
Air pressure required	20 lb.

COAL DUST, *its Influence in Colliery Explosions.* See COLLIERY EXPLOSIONS. (FIRE DAMP, vol. ii. p. 393; SAFETY LAMP, vol. iii. p. 732.)

COLLIERY EXPLOSIONS, *Influence of Coal Dust in producing.* (FIRE DAMP, vol. ii. p. 393; SAFETY LAMP, vol. iii. p. 732.) See OCCLUSION OF GASES IN COAL.

Mr. W. GALLOWAY has drawn attention to the influence of dry coal dust in increasing the sad effects of an explosive mixture of carburetted hydrogen and air in a coal mine. The results of his researches were communicated by Mr. GALLOWAY to the Royal Society and published in the *Proceedings.* From this important paper the following abstract is made.

The first notice we have of the effect of coal dust will be found in a paper on colliery explosions in the *Philosophical Magazine* 1845.

'In considering the extent of the fire for the moment of explosion, it is not to be supposed that fire-damp is its only fuel; the coal dust swept by the rush of wind and flame from the floor, roof, and walls of the works would instantly take fire and burn, if there were oxygen enough in the air present to support its combustion; and we found the dust adhering to the face of the pillars, props, and walls in the direction of and on the side towards the explosion, increasing gradually to a certain distance as we neared the place of ignition. This deposit was, in some parts, half an inch, and in others almost an inch thick; it adhered together in a friable coked state; when examined with the glass it presented the fused round form of burnt coal dust, and when examined chemically, and compared with the coal itself reduced to powder, was found deprived of the greater portion of the bitumen, and in some cases entirely destitute of it. There is every reason to believe that much coal-gas was made from this dust in the very air itself of the mine by the flame of the firedamp, which raised and swept it along; and much of the carbon of this dust remained unburnt only for want of air.'

The subject has attracted more attention in France. In the first number of the *Annales des Mines* for the year 1875 there are some notes referring to it, together with a paper by M. VITAL, Ingénieur des Mines. M. VITAL describes, in a very minute manner, all the phenomena produced by an explosion in the Campagnac Colliery on November 2, 1874. A shot, which blew out the tamping, was fired in one of the working places, in a seam of bituminous coal, which burnt three men so seriously that they died within a week. No fire-damp had been detected in this place at any time; but as the floor was covered with very fine, dry coal dust, and as the shot was fired at the bottom of the face, and would consequently raise a cloud of dust, it was concluded that nothing but the instantaneous combustion of coal dust, under the influence of the shot, could account for the accident.

The writer then describes the nature of the coal dust, both in regard to the size of the particles and their chemical composition; and afterwards he gives an account of some experiments conducted by him in the Rodez laboratory, for the purpose of ascertaining to what extent a flame resembling that of a shot is lengthened when suddenly lanced into an atmosphere consisting of air with fine coal dust suspended in it. In concluding, he says:—'Very fine coal dust is a cause of danger in dry working places in which shots are fired; in well-ventilated workings it may of itself alone give rise to disasters; in workings in which fire-damp exists it increases the chances of explosion; and when an accident does occur, it aggravates the consequences.'

Mr. W. GALLOWAY, conceiving that air with certain proportions of fire-damp and dry coal dust would be explosive at ordinary pressure and temperature, although the presence of the same proportion of one of the combustible ingredients or the other alone might be insufficient to confer this property on the mixture, instituted a series of experiments on the Llwynypia Colliery, in the Rhondda Valley. It is scarcely necessary to describe the apparatus employed. It consisted essentially of a wooden box or pipe, so arranged that a strong current of air could be driven through it. In this a naked flame was placed, and the air charged with every proportion of dust, from a thin and scarcely visible cloud to one which extinguished the flame of the lamp.

The coal dust used was of the following composition, analyses having been made by Dr. FRANKLAND:—

	Steam-coal dust	Bituminous-coal dust
Carbon	86·295	82·570
Hydrogen	5·040	5·100
Oxygen (by difference)	1·261	4·039
Nitrogen	·608	1·050
Sulphur	·692	·800
Moisture	·014	·070
Ash	6·100	5·480
	100·000	100·000

'In some of the experiments with coal dust and air alone, the dust of the bituminous coal was carefully dried and sifted through muslin before being used.

'The results of these experiments, and of others which I have made since, seem to indicate very conclusively that *a mixture of air and coal dust is not inflammable at ordinary pressure and temperature.*

'When, however, a small quantity of fire-damp was allowed to pass into the apparatus, the valve being partly opened to determine an air-current, the mixture of air, fire-damp, and coal dust was found to be somewhat explosive.

'This experiment was conducted in the following way:—A safety-lamp was placed in the apparatus, and the quantity of fire-damp was regulated until the flame of the safety lamp showed no indication of its presence. The safety lamp was then removed and replaced by a naked light, and coal dust was admitted. The effect was instantaneous; for, as soon as the cloud of coal dust touched the flame, an explosion took place, and the box was filled with a red flame, which continued to burn until the supply of coal dust was cut off or the air valves closed. The naked light inside the apparatus was raised up to the top by means of a wire, just before the coal dust was admitted, in order to ascertain that there was not an explosive mixture of gas and air at that point.'

After an explosion in one of the South Wales collieries, all the conditions of the workings were most carefully examined by Mr. Galloway, and he writes:—

'Every circumstance tended to show that some explosive gas had accumulated at the inner end of the level, where there was no ventilating current; that this gas had ignited at one of the naked lights, raising a cloud of dust along the level by its explosion, and that there had been sufficient fire-damp in the air occupying the level to form a weak explosive mixture when the coal dust was added.

'There could be no doubt whatever that the whole of the air in the level contained some fire-damp, so that it became a matter of importance to ascertain the smallest quantity required to make air explosive when coal dust is added; and with this object in view I made further experiments.

'A wooden box was employed, but instead of connecting it to the top of the upcast, a small blowing fan driven by a steam turbine was joined to it at one end, and the other end was left open.

'A fan draws the air into two chambers, one above and the other below the blades; from these chambers the air passes into the fan itself, downwards and upwards through central openings, and is expelled into the apparatus through a tangential pipe.

'The fire-damp pipe passes through one of the air-holes into the lower chamber, and, being turned up at the end, terminates close to the blades.

'The whole of the fire-damp coming from the blower is allowed to pass into the fan; and as there is always an inward draft through the air inlets, the whole of it passes into the apparatus thoroughly mixed with air.

'The qualitative experiment with this apparatus is made in the following way:—The fan having been set in motion, a current of air and fire-damp traverses the apparatus. A safety lamp is then placed in the box, and the velocity of the current is increased by opening the valves until the flame of the lamp gives no indication of the presence of the fire-damp. After this the safety lamp is removed and two naked lights substituted, one opposite each window; and coal dust is supplied through the hopper. As soon as the cloud of coal dust reaches the flame, it takes fire, and either explodes backwards against the current, or fills the box with a red flame, according to the amount of fire-damp in the mixture. Meanwhile the lamp continues to burn exactly as before, showing no indication of the presence of the fire-damp. This experiment is quite conclusive.

'The quantitative experiment is slightly different. A safety lamp is placed, and the valves are closed very gradually until the current becomes explosive; the velocity is then measured by means of a small anemometer, observed through a window. After this the valves are opened to any desired extent; the velocity of the current is again measured; the anemometer is removed, and a naked light substituted for it, and coal dust is admitted.

'I found that the current of air and fire-damp alone was just explosive when its velocity was 155 ft. per minute; and two other observations, made during the intervals between the experiments with coal dust, gave respectively 156 and 153 ft. Again, on January 5 it became explosive at 150 ft. per minute. On the former occasion the velocity was increased to 296, 331, 337, 440, 523, and 543 ft. per minute, and on the latter to 714, 808, 900, and 1,060. At the whole of these velocities the mixture became instantly inflammable when coal dust was added to it, and filled the apparatus with a large smoky flame, which set the wood on fire when continued for more than a few seconds. At a rather higher velocity than the last, the coal dust did

not make the mixture inflammable; I did not, however, determine the exact point at which it ceased to have this effect.

'By other experiments I found that a mixture consisting of 1 volume of this fire-damp and 15 volumes of air is inflammable, and that with 16 volumes of air it is not inflammable at a temperature of 57° Fahr. Making use of these data, then, to calculate the composition of the mixture passing through the apparatus during the last of the second series of experiments, we find that the relative volumes of gas and air were 9·375 and 140·625 at a velocity of 100 ft. per minute; whereas they were 9·375 and 1050·625 at 1,000 ft. per minute, or 1 fire-damp to 112·06 air in the latter case.

'In order to obtain reliable results from these experiments, it was necessary to have some means of ascertaining that the whole of the fire-damp entered the apparatus at the low velocities, and that the fan exerted no exhausting force on the gas pipe in the opposite cases. For this purpose the 2-in. gas pipe was terminated at a distance of 10 in. from the fan, and the gas was conducted from this point to the centre of the fan chamber, through a 1½-in. pipe fitted loosely into the former to a distance of about a foot; a very delicate means of observing the state of the pressure in the gas pipe was also provided by having a small hole punched in it at a distance of 15 ft. from the fan, and keeping a jet of gas continually burning at that point.

'When the velocity of the current was low, gas escaped through the space between the two pipes, and discovered its presence when a light was applied to it. It was then necessary to close some of the air inlets to the fan, either partially or wholly, until a flame held at the junction of the gas pipes was drawn inwards; at the same time the flame of the jet 15 ft. off had to be carefully observed, so that the closing of the inlets might not be carried too far. When the velocity was greatest, on the other hand, all the air inlets were opened; and although air was drawn through the junction of the gas pipes, the height of the flame of the jet already referred to did not diminish to an appreciable extent.'

To recapitulate in a summary manner, we have now two principal facts before us, which are these:—

1. A mixture of fire-damp and air, in the proportion of 1 volume of the former to 60, or more, volumes of the latter, gives no reliable indication of the presence of the inflammable gas, when tested in the manner usually, if not always, adopted in mines.

2. A mixture of fire-damp and air, in the proportion of 1 volume of the former to 112 of the latter, becomes inflammable at ordinary pressure and temperature, when charged with fine dry coal dust, such as that which is to be found on the roadways in dry coal-mines.

It seems, therefore, only reasonable to conclude that an explosion, *originated in any way whatever*, in a mine of this class, may extend itself to remote parts of the workings *where the presence of fire-damp was quite unsuspected.* Mr. Galloway proceeds to say:—

'It is by no means so uncommon as might be imagined to find the air at the face of the workings and in the return air courses of what are considered to be well-ventilated mines showing a cap at least ¼ in. high on the small oil flame. I refer to my own observations in mines abounding in dry coal dust, and reported to be *free from gas*, because no inflammable accumulation was known to exist in them at the time. In these cases the fire-damp appears to be given off quietly at a uniform rate along the face of the coal, but nowhere in such quantity as to render the atmosphere locally inflammable. To give some notion of the volume of gas given off in this way, I need only mention that, in one instance, I found an air current, whose volume amounted to 34,000 cubic feet per minute, showing a cap ¼ in. high. Taking this case as an example, we may suppose the amount of air to be doubled, so that where a cap ¼ in. high was to be found formerly there is now no trace of gas. Then we know that, so long as the coal dust remains undisturbed, naked lights might be used with perfect safety; but let it once be raised and ignited by a small local explosion of fire-damp, or by a shot such as that which caused the explosion in the Campagnac Colliery, and the final results may be of the most serious description. In this way some of the great explosions which have occurred in mines supposed to be almost, if not quite, free from explosive gas may perhaps be accounted for.

'The explosion in the Campagnac Colliery might possibly have been partly due to the presence of a small proportion of fire-damp in the atmosphere of the working place in which it occurred. That place had been driven in coal to a distance of 25 metres beyond the ventilating current of the district, and was ventilated only by an eddy which passed inwards along the floor and returned along the roof; and, although no fire-damp had been found in it, the workmen were provided with a safety-lamp with which they were expected to make a careful examination before igniting a shot. This precaution was considered necessary, since slight explosions had taken place in other

parts of the same mine. Lastly, the working place was quite level, so that it offered no opportunity for an accumulation of explosive gas to be formed in it.

'The most striking circumstance, however, connected with this explosion is that, although it raised a dense cloud of coal dust along the gallery which formed the prolongation of the place in which it occurred, to a distance of from 130 to 150 mètres, the flames did not appear to have extended more than 7 mètres beyond the point at which they first encountered the ventilating current.

'Similarly in the case of the Llan explosion, I found that, at a distance of 15 yards or so beyond the point where the principal air current was met the traces of coked coal dust on the timber began to grow fainter; and although they could be found here and there to a distance of 70 yards further, they were indistinct for the last 40 yards and resembled sparsely scattered grains of gunpowder.

'Before leaving this part of the subject it may not be out of place to make a few remarks on the influence of blasting shots in giving rise to explosions in mines.

'There can be no doubt that the gases which issue from a shot hole have a sufficiently high temperature to ignite an explosive mixture of fire-damp and air if they pass into it immediately. I exploded such a mixture of coal gas and air many times by firing a pistol shot into it when making experiments at the Meteorological Office in the beginning of the year 1873. It seems exceedingly doubtful, however, whether the gases even from a heavily charged shot which blows out the tamping will retain a sufficiently high temperature to ignite a mixture of this kind at a distance of a few yards, if they have to pass through a space filled with pure air before reaching it.'

Mr. W. Galloway makes the following remarks on the influences of changes in pressure and temperature on these lamentable occurrences:—

'The occurrence of three great explosions within as many days in the beginning of December last seemed to indicate the influence of some external agency tending to produce the same result in each individual case. The barometer was high and the temperature at the surface exceptionally low at the time; and it is well known that these atmospheric conditions are not favourable to the occurrence of explosions in which fire-damp alone is concerned. It had been often observed before that disastrous explosions happen most frequently during the winter months, and in some instances during very cold weather. Mr. Scott has recently informed me that he pointed out the latter circumstance in the year 1867 in an official letter to the Home Office; and in preparing the diagrams for our papers on the 'Connexion between Colliery Explosions and Weather,' it was remarked by both Mr. Scott and myself that several great explosions had occurred in the years with which we had to deal (1868 to 1872 inclusive) during weather very similar to that which prevailed in the beginning of December last. This phenomenon was more marked, however, on the last occasion than at any time during my own experience; and while I was investigating the causes of the Llan explosion the following explanation presented itself to me:—

'If we assume that the magnitude of some colliery explosions has been determined by the presence of coal dust in the workings, and that the hygrometric state of coal dust changes with the humidity of the air with which it is in contact, then it is an obvious conclusion that explosions of this kind will be most likely to occur when the air *in the mines* is driest; for at such times not only will the coal dust be most easily raised into the air by the local explosion (which we may always suppose to happen at any rate), but it will also be burned more easily than when it contains a larger proportion of moisture.

'As an example, we may take the case of a dry mine, in which the temperature of the workings is 70° Fahr. During warm weather the air which descends the shaft has a temperature of, say, 60° when it enters the intake air-course; at this stage it is also saturated with vapour, for there is usually a little water trickling down the sides of a mine shaft. The temperature rises gradually as the current draws nearer to the faces, and at length attains its maximum when the newly exposed face of the coal has been passed. During this process the humidity has also been increasing to some extent, always remaining below complete saturation, however, in a mine of this kind.

'In very cold weather, on the other hand, the same current may sometimes have a temperature of 32°, or less, when it reaches the bottom of the shaft; and since it passes through the same workings, its temperature rises to 70° as before. It is plain, therefore, that, in the latter case, the ventilating current must either obtain an additional supply of moisture from the workings (about ½ lb. for every 1,000 cubic feet of air), or it must be *drier* than in the former case at every point of its course.

Primâ facie, then, this process of reasoning leads us to the conclusion that explosions *whose magnitude is due to the influence of coal dust* will happen most frequently during cold weather; and, conversely, we might expect to find that the *magnitude* of those explosions which occur during cold weather is traceable, in some measure, to the influence of coal dust.

COAL GAS. (Vol. ii. p. 438, Gas Coal.) The least trace of acetylene in coal gas can be detected by passing the gas through the ammoniacal solution of the chloride of copper, a blood-red precipitate of cuprosovinyl oxide, $\left.\begin{matrix}C^2HCu^2\\C^2HCu^2\end{matrix}\right\}O$, being formed. Or it may be detected by a very simple method. By placing a gas burner, in which the gas is burning low, under a funnel which is connected with an aspirator, by which the products of combination are passed into an ammoniacal silver solution, a white precipitate is formed.

Allylene, C^3H^4, is a gas resembling acetylene. When the precipitate formed in the above experiment is a greenish yellow, allylene is present.—*A Manual of the Chemistry of the Carbon Compounds*, by C. Schorlemmer, F.R.S.

The articles on Coal Gas and Gas Works in the Second Volume will be found to include everything of real value on the subject of the production of illuminating gas and its purification.

Estimation of Sulphur in Coal Gas.—The author employs the method formerly described by him for the estimation of chlorine, phosphorus, and sulphur in organic substances, viz. burning in a stream of oxygen, and passing the products of combustion over granules of quicklime. The gas to be examined is collected over water in a large flask of some 10 litres capacity, closed by an india-rubber stopper, perforated with two holes; through one of these a glass tube passes, reaching nearly to the bottom of the flask; this is connected with a reservoir by an india-rubber tube furnished with a pinch-cock, so that water can be allowed to enter at will, and expel the gas through a tube passing through the other hole in the stopper, whence it is led to a combustion tube, into which a stream of oxygen is also allowed to pass by means of a doubly perforated cork. This tube is about 12 mm. in internal diameter and 48 cms. long. The end is closed with a pellet of crumpled platinum foil occupying about 2 cms.; behind this is a layer of 10 cms. of granulated quicklime, prepared by igniting the nitrate. The tube is then filled up with fragments of quicklime, and finally a plug of broken glass, surmounted by 20 cms. of finely shred asbestos, or of crumpled-up platinum foil, is inserted.

When the combustion of the gas is completed (which for 10 litres requires $1\frac{1}{2}$ to 2 hours), the quicklime at the further end of the tube is extracted for a length of about 2 cms., dissolved in acid, and tested for sulphate; if none be found, the operation has been successful, and the rest of the lime is dissolved in acid, and the sulphate precipitated by barium in the usual way. If, on the contrary, sulphate be found in the last 2 cms. of quicklime, it is probable that some sulphur has escaped without conversion into calcium sulphates, and the operation should be commenced over again.—G. Brügelmann (*Zeitschr. Anal. Chem.*, xv. 175–180).

M. Berthelot describes the following method of determining the amount of benzene vapour in a volume of coal gas, which need not exceed 15 c.c. The gas, deprived of carbonic acid, is collected over water in a vessel which is closed, when full, by a cork supporting a tube of about 1 c.c. capacity, filled with fuming nitric acid.

The benzene is quickly converted into nitro-benzene by agitation, and after absorbing the nitric vapours by potash, the volume of the residual gas is ascertained by transferring it to a graduated vessel, the initial volume having been previously determined by a careful gauging of the apparatus.

M. Berthelot gives the following figures as representing the quantities of the respective bodies in 1,000,000 volumes of the illuminating gas experimented upon:—

Benzene vapour,	C^6H^6	30,000 to 35,000
Acetylene,	C^2H^2	1,000
Ethylene	C^2H^4	1,000 to 2,000
Propylene	C^3H^6	25
Allylene	C^3H^4	8
Butylene, &c.	C^4H^8	traces
Crotonylene	C^4H^6	31
Terpene	$C^{10}H^{16}$	12
Other hydrocarbons		95

Comptes Rendus, lxxxii.

COAL, *Gases enclosed in.* The gases actually enclosed in coal were first subjected to examination by Dr. Ernst von Meyer, who published his results in 1872 (*Journ. pr. Chem.* (2) v. 144–183), which were abstracted in the *Journal of the Chemical Society* (N.S. vol. x. p. 708). Dr. Meyer states that the gases employed in this research were obtained from the coals by introducing two to four hundred grains into a flask, which was immediately filled up with hot de-aerated water, which was then boiled so

as to expel the gases from the coal, and drive them through a short straight tube into a number of tubes inverted in a basin of water.

The quantity of gas contained in 100 grams of various coals freshly raised and long weathered is shown in the following table:—

	Freshly raised	Weathered
1. Zwickau coal gave	39·0 c.c.	a. 18·0 c.c.
2. " "	25·5 "	a. 18·6 "
3. " "	54·8 "	a. 13·6 "
4. Westphalian from Essen gave	22·5 "	—
5. " " Bochum gave	50·6 "	a. 13·2 "
6. " "	54·4 "	a. 30·2 "

The composition of the gases from the fresh coal was found to be as follows:—

	CO^2	O	N	CH^4
1 . .	2·42	2·51	23·27	71·0
2 . .	4·02	0·62	50·86	45·00
3 . .	0·6	trace	48·0	51·4
4 . .	7·5	2·59	89·91	—
5 . .	4·87	2·86	75·62	16·65
6 . .	1·30	1·60	66·85	30·25

The composition of three samples of weathered coal was found to be—

2 a . .	2·25	0·7	23·89	73·16
5 a . .	11·12	2·88	78·6	7·4
6 a . .	4·35	3·35	81·18	11·12

These numbers show that exposure to the weather causes a considerable loss of the marsh gas. Dr. Meyer remarks, 'The ratio of oxygen to nitrogen and carbonic acid also serves to show that, in the process of the passage of vegetable remains into coal, the oxygen of the air concerned has gone mostly to the burning of the hydrogen, leaving the carbon comparatively intact.'

This does not appear so evident as Dr. Meyer thinks it to be. The analyses are given as the first that were made, and they are of considerable interest and value; but there are evidently some discrepancies between the quantities of nitrogen given and those of marsh gas, which it is not easy to reconcile.

Dr. Ernst von Meyer also examined the gases enclosed in English coal, from the Durham and Newcastle coal field. *Journ. pr. Chem.* (2), v. 407–416, abstracted in *Journal of Chemical Society*, in connection with the previous paper.

Name of Colliery	100 grams gave	CO^2	CH^4	O	N
	c.c. gas				
1. Bewicke Main, Low Main Seam . .	25·2	5·53	6·52	2·28	85·65
2. " Maudlin Seam .	30·7	8·54	26·54	2·95	61·97
3. Urpeth, Main Coal Seam . . .	27·4	20·86	—	4·53	74·31
4. " ⅚ Seam (30 fathoms from surface)	24·4	16·51	trace	5·65	77·84
5. Wingate Grange, Low Main Seam (74 fathoms from surface) . . .	91·2	0·34	85·8	trace	13·86
6. Wingate Grange, Low Main Seam (108 fathoms from surface) . .	238·0	1·15	84·04	0·19	14·62
7. Wingate Grange, Harvey Seam (148 fathoms from surface) . . .	211·2	0·23	89·61	0·55	9·61
8. Woodhouse Close, Harvey Seam (20 fathoms from surface) . . .	84·0	5·31	50·01	0·63	44·05

Taking the specific gravity of coal as 1·3, it will be seen that Nos. 6 and 7 contain nearly three times their volume of gases measured at ordinary pressures, and that therefore, as the coal is very hard and dense, the condensation of that gas must be very great. This is the remark of the abstraction, but the results obtained by Mr. Thomas will show that the closer the structure of the coal the greater is the quantity of gas occluded.

Dr. E. v. Meyer examined also the gases from the coals of the Saar district (*Journ. pr. Chem.* (2), vi. 389–416). The gases from four pits were examined, but it is not clear whether the gases were those contained in the coal or obtained from the workings. These, therefore, are omitted, but the results are very nearly those obtained from the Durham coal.

At this point the enquiry was taken up by Mr. W. J. Thomas, who published the results of his enquiries in a paper read before the Chemical Society, bearing the title, *On the Gases enclosed in Coals from the South Wales Basin, and the Gases evolved by Blowers, and by Boring into the Coal itself*, and published in the *Journal of the Chemical Society* for September 1875.

Mr. Thomas proceeded as follows in making his experiments:—Slices of coal were sawn out of the middle of large cubes, and a strip about ⅜" in thickness and 6" to 8" in length was next cut from the middle of this slice, the edges rounded off, so as to make it slide readily into a glass tube of the proper diameter. The coal was brushed with a feather to remove any adhering dust, and speedily placed in a glass tube, one end of which had previously been drawn out into a long neck, so as to form a connection with the Sprengel mercurial pump. The other end was then sealed off before the blowpipe, at a sufficient distance from the coal to prevent any material rise in temperature. The usual water-joint connection was then made with the Sprengel pump, the air exhausted as quickly as possible, until almost a perfect vacuum had been obtained, and the last portion of the gases which was brought over collected and subjected to analysis. Mr. Thomas proceeds to say:—

'Many of the bituminous and steam coals of the South Wales field are of a porous nature, and far from hard or dense; and from their physical aspect it appeared probable that, on withdrawing the air from around the strips of coal, and on the formation of a partial vacuum, a large portion of the gases enclosed in the coal would escape. This was not found to be the case, however, as very little gas was evolved from any of the coals which I had occasion to examine, even when almost a complete vacuum was obtained, and the amount of gases so given off rarely exceeded 2 or 3 c.c. per 100 grams of gas. Some of the steam and bituminous coals, which were hard and laminated, as well as the still harder and denser anthracites, evolved only traces of gas, whilst the enclosed gases were rapidly given off as soon as the temperature was raised.

'When the whole of the air had been removed, the tube containing the coal was immersed in boiling water, and kept at a temperature of 100° C. for about seven hours, or until the mercury pump ceased to bring over any appreciable quantity of gas. The gases thus evolved were collected in graduated glass tubes.

'From 10 to 30 grams of coal were usually employed in each experiment, according to the nature of the coal and the quantity of gas evolved, a very small quantity of anthracite being sufficient to furnish an ample amount of gas for analysis, whilst highly bituminous coals gave off so little gas, that 30 grams of coal were required to yield the necessary volume.

'The rapidity with which the occluded gases are evolved, under a vacuum at 100°, depends upon the hardness of the coal and the quantity of gas enclosed. By far the greater portion of the gases given off at that temperature is brought over by the pump during the first three hours.

'Still the whole of the enclosed gases present in these coals is not withdrawn at 100°, nor even at 200°, and there remains a considerable quantity still imprisoned in the pores of the coals after having been kept at that temperature for hours. In a few instances I proved this by heating the coal up to 300°, or close upon the point where decomposition takes place.' This fact, Mr. Thomas remarks, is of considerable importance, as it shows that Meyer could only have worked with that portion which is forced from the coal at the temperature of boiling water.

	Gas evolved from 100 grams of coal at 100° C.	Analysis of gas evolved in 100 parts			
		Carb. Anhyd.	Oxygen	Marsh Gas	Nitrogen
1. Bituminous Coal, from a level at South Pit, Plymouth Iron Works	55·0 c.c.	36·42	·80	—	62·75
2. Bituminous Coal, from South Pit, Plymouth Iron Works .	61·2 ,,	16·77	2·72	·40	80·11
3. Bituminous Coal, from Cwm Clydach, No. 3, Rhonda .	55·1 ,,	5·44	1·05	63·76	29·75

	Gas evolved from 100 grams of coal at 100° C		Analysis of gas evolved in 100 parts			
			Carb. Anhyd.	Oxygen	Marsh Gas	Nitrogen
The tube containing the coal was left exposed to air for 11 weeks and 2 days, then connected with Sprengel's pump, and heated to 100° C. for seven hours . .	33·2	c.c.	11·10	7·67	9·31	71·92
4. Semi-bituminous Coal, Bute Merthyr, Rhonda Dist. .	73·6	,,	12·34	0·64	72·51	14·51
5. Steam Coal, from Bute Merthyr, 3 feet 9 inch seam .	194·8	,,	5·04	0·33	87·30	7·33
6. Steam Coal, from Navigation Colliery, upper 4 feet seam .	250·1	,,	13·21	0·49	81·64	4·66
7. Steam Coal, Dunraven Colliery, upper 4 feet seam .	318·4	,,	5·46	0·44	84·22	9·88
8. Steam Coal, Cyfarthfa, upper 4 feet seam	147·4	,,	18·20	1·02	67·47	12·61
9. Steam Coal, Bute Merthyr, 6 feet seam	375·4	,,	9·25	0·34	86·92	3·49
This coal was broken to pieces and exposed to the atmosphere for 14 weeks, then subjected to 100° C. for 7 hours under a vacuum . .	112·3	,,	11·75	2·64	54·78	30·83
10. Steam Coal, Dunraven Colliery	149·3	,,	11·35	0·56	73·47	14·62
11. Steam Coal, Duffryn Colliery .	215·4	,,	5·61	0·54	82·70	11·12
12. Bituminous Coal, Betwys Coal, Ogmore Valley . . .	24·0	,,	22·16	6·09	2·68	69·07
13. Bituminous Coal, Lantwit .	39·7	,,	9·43	2·25	31·98	56·34
The tube containing the coal was exposed for 10 weeks to air, then exhausted, and heated to 100° C. for 7 hours	31·2	,,	18·62	7·94	7·86	65·58
14. Anthracite, Bonville Court .	555·5	,,	2·62	none	93·13	4·25
15. Anthracite, Watney's Llanelly	600·6	,,	14·72	—	84·18	1·10
Heated in a bath of paraffin at 200° C. for 8 hours . .	903·1	,,	8·06	—	91·83	·11
After standing in vacuo at 12° C. for 41 hours . . .	16·1	,,	—	—	—	—
Further heated at 300° in paraffin bath	206·5	,,	1·43	—	98·47	10·
The total volume of gas evolved	1875·9	,,	—	—	—	—
16. Nine grams of this coal taken from the centre of a large lump, exposed to the atmosphere for 4 weeks, then exhausted .	731·1	,,	14·60	—	81·34	4·06

Mr. W. J. Thomas makes the following deductions from his carefully conducted experiments:—

'The gases from the three classes of coals which were analysed differ, as might be expected, both in quality and even more so in quantity. The bituminous coals, when on or near the surface, contain little or no marsh gas, and the percentage of carbonic anhydride is usually very high. The quantity of gas which they yield is much smaller than that given off by either steam coal or anthracite. It would indeed be possible to arrive at a pretty safe conclusion as to the bituminous character of a coal by analysing the enclosed gases, and taking into account the quantity. It will also become readily apparent that seams of bituminous coal can be and are worked all over South Wales with naked lights, as they contain little or no marsh gas, and the few samples taken from deeper levels which contain a high percentage of the same still differ materially from the steam coal and anthracite, by giving off comparatively small

quantities of gases only. The real difficulty of working these seams arises, in fact, not so much from the presence of marsh gas as that from carbonic anhydride. On no occasion did I meet with any carbonic oxide, however, although I looked carefully for this poisonous gas.'

Steam coals evolve a much larger quantity of gas than bituminous, and their composition also differs by showing invariably a very high percentage of marsh gas, as much in fact as 87 per cent. The volume of gas depends in a great measure upon the hardness and porosity of the coals, and upon the time which has elapsed since they were removed from their respective seams or veins: this latter applies equally to all coals.

Hard compact steam coals, especially those showing laminated structure, evolve a quantity of gas approaching to that given off by anthracites.

Steam coal also gives off a considerable quantity of gas at 200° after having been previously heated at 100° C. for some hours.

Anthracites yield by far the largest gas volumes; e.g. sample 15, of specific gravity 1·35, and giving on analysis 2·07 per cent. of hydrogen, yielded from 100 grams of coal as much as 600 c.c. of gas when heated at 100° for seven hours. On heating it to 200° for eight hours, close upon 1000 c.c. of gas were obtained, whilst at 300° a still further quantity was given off, the gas obtained amounting altogether to 1875·9 c.c. for 100 grams of coal.

The composition of the gases evolved from anthracite closely resembles that from steam coal; the only difference appears to be that the anthracites from the western part of the coal basin occlude more marsh gas and less carbonic anhydride, and that they are absolutely free from oxygen, while steam coal as a rule showed traces of oxygen. It is worth observing, that the gases evolved from anthracite at 100°, 200°, and 300°, are analogous in composition, in so far as they consist of carbonic anhydride—marsh gas and nitrogen only—but that the percentage of the latter is reduced to a mere trace; also, that the percentage of carbonic anhydride decreases, leaving a gas volume consisting almost entirely of marsh gas.

The fact must not be lost sight of, that these conclusions refer only to anthracites when examined in the laboratory; neither must it be taken for granted, because a coal contains a large volume of occluded gases, even when such gases consist mainly of marsh gas, that the seam or vein from which it is derived is a fiery one, and one that requires great caution in working. The very reverse is indeed the case. Now, although steam coal yields less gas than anthracite, it must not be supposed for a moment that it is, therefore, safer to work the former. Steam coal, before being removed from the seam or vein, holds enclosed a much larger quantity of gas. Being less hard and more porous, the gas escapes from it in vastly increased quantities over that from anthracite. The volume of gas rushing out from the face of most steam coals is so enormous, as to be almost incredible, whilst little gas escapes from a working face of anthracite coal. The great hardness and jet-like structure of the latter accounts in a great measure also for the large volume of gas which it holds enclosed, and it is probable that its formation must have taken place under such immense pressure that the gases generated during the transformation of the organic matter into anthracite were not able to make their escape. The results obtained must not be thought to lead to the conclusion, that because a coal contains a large volume of occluded gases, even when such gases consist mainly of marsh gas, that the seam or vein from which it is derived is a fiery one, and one that requires caution in working.

These experimental results are of the highest value, showing, as they do, that according to the structure of the coals so is their power of holding gases by a pure mechanical force—occlusion—in a state of extreme tension. The fact that anthracite holds a much larger quantity of gas than steam coal does appears to be dependent upon the closer structure of the anthracite, and this also prevents its escape under circumstances which allow the gas in the steam coal being freely evolved. If Mr. Thomas is right in his conjecture that the gases contained in anthracite were generated during the transformation of organic matter into anthracite, we must reject the view that anthracite has been formed by the action of heat, driving off from bituminous coal some portion of the hydrocarbon elements which give to it its peculiar character.

That hypothesis is, however, supported by so large an amount of evidence, that it is desirable that we should consider whether the anthracite—after the period of its conversion from bituminous coal—may not by virtue of its change have absorbed the gases slowly evolved from the more volatile varieties of coal, and retained them, as Mr. Thomas has proved they do, until liberated by the combined agency of heat, and relief from atmospheric pressure.

The conditions which render some seams of coal fiery, while others are not so, are very satisfactorily explained by these very interesting experiments.

Gases enclosed in Cannel Coals and Jet.—The method used was similar to that previously adopted for anthracite and bituminous coals.

	Gas evolved from 100 grams of coal at 100°.
1. Wigan Cannel from Wigan Arley Mine . . .	421·3 cubic centimètres.
2. Wigan Cannel	350·6 ,,
3. Scotch Cannel, Haywood Colliery, Wilsontown .	16·8 ,,
4. Lesmahago Cannel	55·7 ,,
5. Cannel Shale, Lasswade, Edinburgh . . .	16·7 ,,
6. Whitby Jet	30·2 ,,

Analyses of the Gas evolved.

	Composition in 100 parts					
	I.	II.	III.	IV.	V.	VI.
Carbonic anhydride . .	6·44	9·06	53·94	84·55	68·75	10·93
Marsh gas	80·69	77·19	—	—	—	—
Hydride of ethyl . . .	4·75	7·80	—	—	—	—
Nitrogen	8·12	5·96	46·06	14·54	28·58	2·17
Traces of hydrocarbon . .	—	—	—	—	—	—
Gases and vapour of the $C^nH^{2n}+2$ series agreeing with C^4H^{10}	—	—	—	0·91	2·67	—
Quartane or ethyl . . .	—	—	—	—	—	86·90

The whole of the cannel coals and jet contain the gases of the paraffin series and oily matters which appear to belong to the same. Wigan cannels, with regard to the gases which they hold enclosed, occupy a position intermediate with steam and Scotch cannel; and Scotch cannel occupies a position intermediate with bituminous house coals and Wigan cannel. Thus in the Wigan cannels there is a large volume of gas, consisting for the most part of marsh gas, with a low percentage of carbonic acid and nitrogen, and in these respects closely allied to the steam coals. The Scotch cannels, on the other hand, contain but little gas, which consists almost entirely of carbonic anhydride and nitrogen, similar to the bituminous class of house coal. Scotch cannel contains a small quantity of the higher carbon gases. Owing to the high percentage of carbonic anhydride present it became possible to employ a large and concentrated volume for the determination of the combustible gases.—'*On the Gases enclosed in Cannel Coals and Jet*,' by J. W. Thomas: *Journal of the Chemical Society*, August 1876.

COAL, *Gases escaping from.*—In immediate connection with the preceding subject it is necessary to consider the characters of the gases escaping from the coal in the mine. Bischoff has stated that those gases were the light carburetted hydrogen, carbonic acid and olefiant gas—and that they were the products of distillation and not those of decay. The experiments made by Mr. Thomas prove them to be neither the one nor the other. They are clearly proved to be the gases occluded by the coal, liberated by the removal of the pressure which acts in addition to the force—occlusion—which belongs to the structure of porous bodies. The results obtained by nearly all chemists who have studied this subject confirm this. Professor Graham, in the *Memoirs of the Chemical Society*, vol. ii. p. 7, gives the results of his examination. The general result of his analyses show, a mixture of light carburetted hydrogen, with a small mixture of nitrogen and oxygen as common air. Dr. Lyon Playfair, in 1846, published in the *Memoirs of the Geological Survey of Great Britain* a paper '*On the Gases evolved during the Formation of Coal.*' It would have been safer to have called this paper 'on the gases evolved from coal in the coal mines,' seeing that there is no evidence that those gases had anything to do with the coal at the time of its formation. The results, however, are so satisfactory that it is thought right to give some of his analyses, before we give those more recently obtained by Mr. Thomas.

Name of Colliery	Marsh Gas	Carbonic Acid	Nitrogen	Hydrogen	Oxygen
Hebburn. From a seam of coal 24 feet below the Bensham seam . .	91·5	0·7	[illegible]	—	0·9

Name of Colliery	Marsh Gas	Carbonic Acid	Nitrogen	Hydrogen	Oxygen
WALLSEND. From a fiery coal at a depth of 150 fathoms	92·8	0·3	6·0	—	—
JARROW. Bensham seam	83·1	2·1	14·2	—	0·6
HEBBURN PIT. Bensham seam from a blower at the depth of 161 fathoms .	86·5	1·6	11·9	—	—
WALLSEND. Bensham seam	77·6	1·3	21·1	—	—
OAKWELL GATE. From the five quarter seam 33 fathoms from surface . .	98·2	0·5	1·3	—	—
JARROW. Five quarter seam . . .	93·4	1·7	4·9	—	—
JARROW. Low main seam	79·7	2·0	12·3	3·0	3·0

Pursuing the enquiry, which we have already described, on the gases occluded by coal, Mr. THOMAS was induced to examine the gases which escaped from the coals in the seams, either by blowers which developed themselves during the working of the coal, or such as were obtained by boring into the coal. In the following list this is distinguished:—

Gases obtained from Borings or Blowers.

Name of Colliery	Marsh Gas	Carbonic Acid	Nitrogen	Oxygen Air	Nitrogen Air
DUNRAVEN, TREHERBERT. (*Blower.*) Top rock 6 feet seam, 225 yards from surface	97·65	·50	1·85	—	—
DUNRAVEN. (*Boring.*) By boring into the coal 6 feet seam 225 yards from surface . .	97·31	·38	·31	—	—
DUNRAVEN. (*Boring.*) By boring into the coal 4 feet seam 125 yards from the surface .	96·54	·14	3·02	—	—
DUNRAVEN. (*Blower.*) Obtained from the top rock 4 feet seam 125 yards from surface .	96·74	0·47	2·79	—	—
FOCHRIEW, MERTHYR DISTRICT. (*Boring.*) By boring into the coal 6 feet seam 295 yards from surface .	74·88	·15	2·53	4·69	17·75
PLYMOUTH, MERTHYR. (*Boring.*) By boring into the coals 4 feet seam 300 yards from surface .	95·42	·60	3·98	—	—
PLYMOUTH. (*Blower.*) Gas from top rock of the 4 feet seam, south pit, 300 yards from surface (water oozed out with the gas) . . .	94·84	·10	5·06	—	—
FORCHAMMON, ABERDARE. (*Blower.*) Top rock of the 6 feet seam 230 yards from surface . .	95·05	4·26	·69	—	—

Name of Colliery	Marsh gas	Carbonic Acid	Nitrogen	Air
FERNDALE, RHONDDA DISTRICT. (*Blower.*) From a rent on top rock of the 4 feet seam	47·37	·90	3·13	48·60
BUTE, MERTHYR, RHONDDA. (*Blower.*) From a heading connecting the upcast and downcast shafts 20 yards above 2 feet 9 inch seam, and 80 yards from the surface	95·47	·62	3·91	—
MAESTAD, MERTHYR. (*Blower.*) From floor of a hard heading, between 6 feet and 9 feet seams, 140 yards from surface	95·51	1·96	2·53	—
LLWYNYPIA, RHONDDA. (*Blower.*) Obtained from the lamp room .	94·75	·72	3·60	Hydride of Ethyl 0·90
CWM-PARK, BROOK. (*Blower.*) Gas collected from the side where it escaped in large quantities .	95·56	0·35	3· 8	Oxygen 0·11

COAL OIL *of Japan.*—Coal oil is found in considerable quantities in Japan, especially in the neighbourhood of Nügata. Near Kurakawa 80 pits have been sunk, one of which is said to yield from 4 to 5 'to' of oil a day (a Japanese 'to' is equal to about 16 quarts). During the last six months of 1874 the province of Echigo alone produced no less than 284,983 Japanese 'shoo' (107,243 gallons) of oil, worth 11,439 'yen' (2,835*l.* 9*s.* 3*d.*). The production of Shinano, Ugo, and Tatomi in coal oil is small, but the actual quantity is not known.

The quality of the Japanese oil is very good; and it is considered that the supply might be much increased if worked judiciously. At present the quantity produced is insufficient for competition with the American oil even in Yedo or Yokohama; it is entirely consumed in the localities where it is produced. The oil is usually refined by a single distillation; and up to the beginning of the year 1875 no sulphuric acid was used, but from that date we hear it has been employed.

COALS RAISED *by Hydraulic Pressure.*—Mr. GEORGE FOWLER has introduced some new arrangements of great value for loading and unloading pit cages. In addition to incidental advantages, Mr. D. P. MORISON, in a paper read before the North of England Institute of Mining and Mechanical Engineers, claims for this invention—

1. Increasing the efficiency of (by utilising to the utmost) existing winding gear without the excessive wear and tear usually accompanying high speeds; and,

2. Reducing the first cost of winding engines for new works by working them under more favourable conditions, requiring less power to perform a given duty.

These objects are effected by the use of auxiliary on-setting and pulling-off gear in loading and unloading the pit cages, enabling the time of the winding engine to be devoted more to its legitimate duty of raising coals, and less to the unprofitable work of striking the cages.

The hydraulic winding gear as seen at the top of the pit is shown at *fig.* 2295.

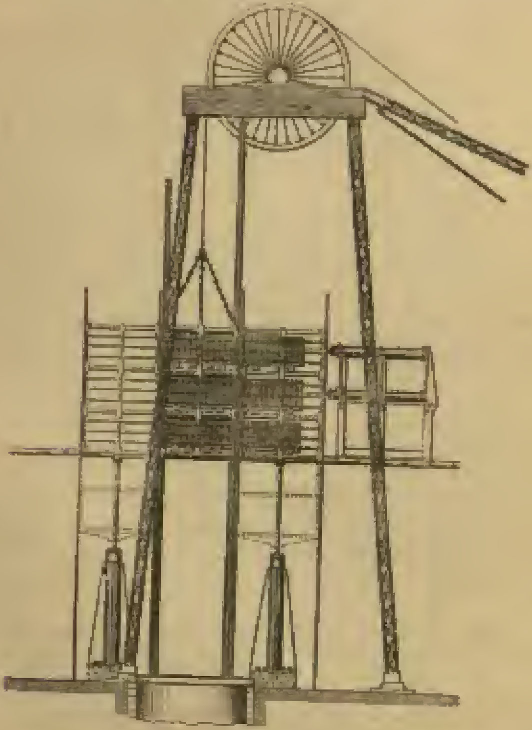
The striking of the cages is avoided in the manner shown in *fig.* 2296, representing the cage at bank, settled on the keps, and ready to be relieved of its load. The platforms, A A A, contain the empty tubs to be placed on the cage, and the platforms, B B B, are prepared to receive the loaded tubs.

The lowest of the three loaded tubs is drawn over the platform B on to the bank rails, and the lowest empty tub is pushed on the cage by manual labour in the ordinary manner. Simultaneously with this, however, the two upper empty tubs, F F, are thrust forward by the hydraulic rams C C, and displacing the two upper loaded tubs take their places on the cage. The catches for retaining the empty tubs on the cages are then all put into position by the movement of one rod (not shown), and the cage is ready to proceed on its downward journey. The time required for these movements is of course precisely the same as would be necessary for a single-decked cage loaded

with one tub. The actual pulling-off and on-setting on the part of the banksmen now begins, but for these duties there is ample time while the cage is running, the principal object having been attained, namely, getting the machinery again at its proper work of winding.

The two platforms A and B are then allowed by the hoists D and E to sink into the successive positions necessary for changing. A is ready to be charged with empties, its decks being successively brought by the hoist to the bank level of rails, and B, having been allowed by similar means to bring its middle deck to the bank level, can be further lowered for the removal of the uppermost loaded tub.

2295



Platform B, after being relieved of the weight of tubs and coal, is overbalanced by the counterweights W W (shown on plan), and, steadied by the hoist E, rises to its former position.

The whole arrangement is repeated at the bottom of the shaft, the time available for changing being of necessity greater there than at bank, since the cage descends at once on the keps, without waiting for the reversing of the engine.

The rams C C for setting on the empties and pushing off the loaded tubs, as well as the hoists D and E for altering the level of platforms, are actuated by hydraulic pressure maintained by a small donkey engine, which pumps into an accumulator arranged in the usual and now well-known manner. The ram of the accumulator is about 6 in. diameter, with a stroke of 5 ft., which is found quite large enough for any demands made upon it. The speed of the donkey engine is regulated by the position of the ram, which opens and closes a throttle valve, without needing attention, so that the quantity of water pumped is exactly as much as is required. The same water is used over and over again, the exhaust from all the rams being discharged into a small reservoir; the waste is therefore extremely small, being only that arising from leakage, and it is proposed to prevent freezing in the pipes in winter by mixing methylated spirit with the water. About 500 lb. pressure on the square inch has

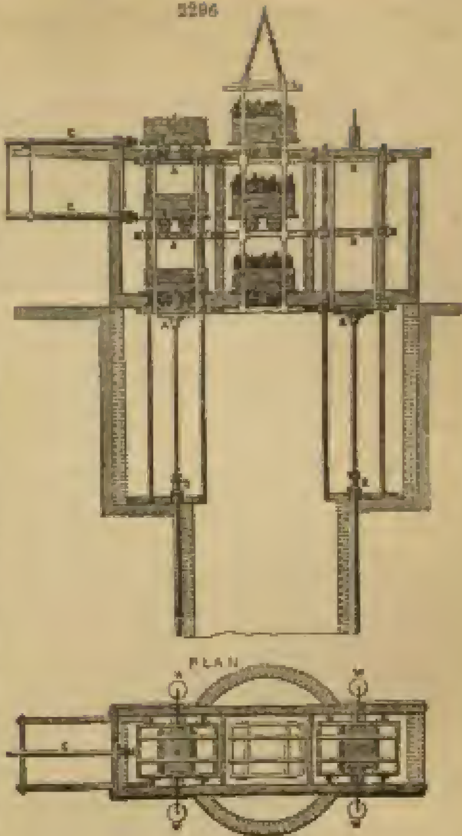
been found most convenient for working the rams and the hoists, but the experience of each special case would determine the pressure most suitable, which can be readily adjusted by the weights on the accumulator.

A valve, consisting of an ordinary three-way tap, is used for admitting the water pressure simultaneously to the rams C C, and is opened and closed by the on-setter.

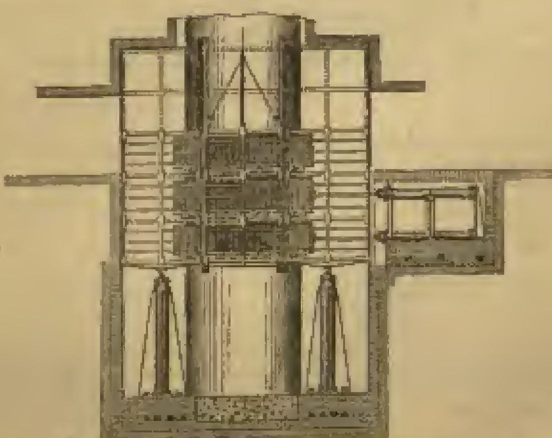
After the rams have pushed forward the tubs, they are almost instantly brought back to their former position by the water pressure acting on the annular space in front of the small pistons with which they are provided. The valves for raising and lowering the platforms are at present worked by a man conveniently placed for the purpose, but they may be arranged so as to be under the control of the men employed in changing the tubs.

At the bottom of the shaft the accumulator and donkey engine are dispensed with, and the hydraulic pressure is obtained directly from the head of water contained in a pipe tapped into the tubbing. The suitable height at which the pipe should be attached to the tubbing is easily found when the pressure most convenient has been ascertained by trial

2296



2297



with the accumulator. If, however, the desired position is not available, either by reason of the absence of tubbing, or in consequence of the head of water already in

the tubbing being excessive, any greater height may be adopted, and the superfluous pressure negatived by turning up the exhaust pipe so as to discharge at a higher level than would otherwise be necessary. The water, after being used, is conducted to the pump, from which it is drawn with the ordinary pump water. In the case of a downcast pit, it will be necessary to prevent freezing in the pipes and tubbing by the use of a steam jet or other means. *Fig.* 2297 shows the arrangements at the bottom of the pit.

The saving of time is more considerable than would at first sight appear. In the case of a three-decked cage, changing the tubs in the ordinary way occupies of course exactly three times as many seconds as would be required for a single deck. But, in addition to the time actually devoted to changing, there are the intervals necessary to raise the cage to a different level and settle it on the keps, during which the changing cannot proceed, and the banksmen can only look on while the cage is being brought into position. And these intervals are of necessity of considerable length, especially in the case of heavy winding gear, since the inertia of a large mass weighing many tons has to be overcome every time the winding engine is reversed. It is by transferring the idle intervals of time from the cage to the platforms that the principal saving is effected, for usually as much time is consumed in getting the two lower decks into place as would suffice to change the three tubs one after the other.

This will be made clearer by the following table, showing the manner in which the time is distributed to the various movements required to strike a three-decked cage and change the tubs.

It is the average result of many experiments made when no hindrance took place from accidental circumstances:—

TABLE No. 1.

	Three-decked cage.
1.—Settling on the keps	1 second.
2.—Changing No. 1 deck	$5\frac{1}{4}$ "
3.—Lifting cage 5 ft. 6 in.	$3\frac{1}{2}$ "
4.—Settling on the keps	1 "
5.—Changing No. 2 deck	$5\frac{1}{4}$ "
6.—Lifting cage 5 ft. 6 in.	$3\frac{1}{2}$ "
7.—Settling on the keps	1 "
8.—Changing No. 3 deck	$5\frac{1}{4}$ "
9.—Lifting cage to clear keps	$1\frac{1}{2}$ "
	28 "

TABLE No. 2.

	Two-decked cage.
1.—Settling on the keps	1 second.
2.—Changing No. 1 deck	$5\frac{1}{4}$ "
3.—Lifting cage 5 ft. 6 in.	$3\frac{1}{2}$ "
4.—Settling on the keps	1 "
5.—Changing No. 2 deck	$5\frac{1}{4}$ "
6.—Lifting cage to clear keps	$1\frac{1}{2}$ "
	18 "

With the aid of the hydraulic apparatus, most of the above items may be struck out altogether, and the table then stands as follows:—

TABLE No. 3.

1.—Settling on the keps	1 second.
2.—Changing all the decks	$6\frac{1}{2}$ "
3.—Lifting cage to clear keps	$1\frac{1}{2}$ "
	8 "

This (8 seconds) is the time actually occupied in changing a three-decked cage at Hucknall Colliery, with the apparatus described under favourable circumstances, which, for purposes of comparison, have been assumed for all three tables. The average time is 10 seconds, and the minimum 7 seconds.

Taking the case of a pit 300 yards deep, the time of actual running in the shaft occupies (from trial) 35 seconds. The total time for each journey, including the changing of tubs, would be—for a three-decked cage worked in the ordinary manner,

35 + 28 = 63 seconds, or 57 journeys per hour. With the hydraulic apparatus the time would be 35 + 8 = 43 seconds, or 84 journeys per hour. The efficiency of the winding engines would thus be increased nearly 45 per cent.

Applying the same reasoning to a two-decked cage, we have in the one case 35 + 18 = 53 seconds, or 68 journeys per hour; and in the other case 35 + 8 = 43 seconds, or 84 journeys per hour. The increased efficiency is then nearly 24 per cent.

The increase in the quantity of coal raised with the aid of the gear now described and at work, amounts to about 300 tons per day, making a total of 850 tons per day.

It will readily be seen that if the winding capabilities of an existing engine can be increased 40 per cent., the power and cost of a new one to perform a given amount of work may be reduced in the same proportion.

Some of the incidental advantages obtained from the gear will be apparent from the following considerations:—

To bring a three-decked cage into the different required positions, the winding engine has to be reversed six times, without counting the extra complication of striking the cage at bottom, and the final reversing for the regular journey, which is necessary in all cases. For a single-decked cage, or any to which the hydraulic gear is applied, two reversings only are requisite. Thus four reversings at least are saved, each of which would on the average consume a cylinder full of steam (more or less, according to the accidental position of pistons), besides the clearance spaces and steam ports, which for two cylinders is about two-fifths more.

This space of a cylinder and two-fifths has to be filled with steam of full pressure before any movement of the cage takes place, as the inertia of the machinery and ropes has to be overcome. The saving being effected at least four times each journey is an appreciable quantity, and goes far to compensate for the extra demand made upon the boilers to supply steam for the more numerous journeys per day which are rendered possible. The advantage of reversing the engine and lifting the cage as seldom as possible, applies to the ropes with still more cogency, since the repeated snatching strains are avoided, which do more to shorten the working life of a rope than the regular running which is its proper duty. It is clear that all the lifting performed by the hydraulic hoists represents so much work, of which the ropes as well as the engines are relieved, and the economy thus resulting is expected to be an important one, the extent of which can only be shown by further experience. It may, however, be suggested that an arrangement which admits of smaller engines and lighter ropes to perform a given duty, must also be directly conducive to economy in the consumption of steam, as the work required to accelerate the inert mass contained in the machinery generally is materially reduced. It should be remembered that, in rapid winding, this work of bringing up the speed of the engines is for the most part lost, it being absorbed afterwards by the break, and by the resistance caused by closing the valves of the engine.

The water pressure in the accumulator may be made available for other purposes as well as those in connection with the present subject, such as working hoists for raising coals to the screens, actuating the break of the winding engine when extra power is required, &c.

The economy in manual labour arising from the use of the new gear is worthy of consideration, even with regard to the cost per day, but when estimated in connection with the increased quantity of coal raised, it becomes important; as, besides the banksman, the engine drivers and firemen are working with better results from their day's exertions.

Coals raised from Great Depths by Atmospheric Pressure.—Circumstances directed the attention of M. Blanchet, Director of the collieries and railway at Epinac, to the possibility of using the pressure of the atmosphere to extract coals from pits of great depth. In the pit at Hottinguer he substituted, for the second or upcast shaft, a wrought-iron tube, and made this tube a cylinder in which a piston with the cages suspended should traverse by the action of the air without using ropes. The pit being 16 ft. in diameter, he was enabled to put the tube within it. The air was extracted from the tube, because this did not produce heat, and he succeeded by exceedingly simple means, in causing the ascent and descent of nine tubs placed one above another in the cage, and putting them out at bank with facility.

For the following description of the apparatus manufactured at Creusot for the Hottinguer pit we are indebted to Mr. Theodore Wood Bunning, Secretary of the North of England Institute of Mining and Mechanical Engineers:—

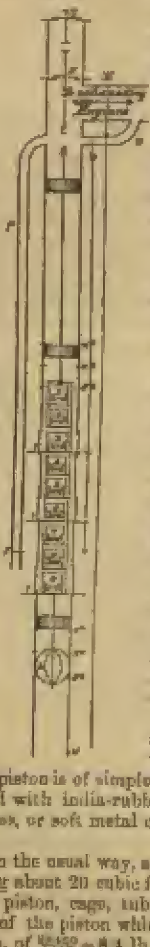
Fig. 2298 shows the cage at the bottom of the shaft, while *fig.* 2299 shows the cage at bank.

'A cylindrical tube 63 in. diameter and about $\frac{3}{16}$ths of an inch thick, made of plate iron, rivetted together with butt joints and countersunk rivets, runs from top to bottom of the pit. It is made in about 20-ft. lengths, and joined together by means of flanges

and bolts. Each length is hammered to a perfectly cylindrical form upon mandrils passed through for that purpose.

2298

2299



'It was thought for some time that these tubes would have to be bored out, but the experiments at Epinac have shown that, made as described above, the ordinary lubrication of the tube is sufficient to render it tight at the pressure and temperature required.

'This tube is placed in a special compartment of the pit, from the sides of which it is isolated. It is supported every 10 ft. by buntings similar to those used for supporting the pumps. These buntings are so arranged that at any time a single tube can be withdrawn without disturbing the others.

'To render the whole independent of any movement that might take place in the pit, the buntings are not firmly built in the sides, but are free to slide upon two smaller buntings in the lining. The piston is made in two parts, one at the top and the other at the bottom of the cage. The top piston is made of two platforms at such a distance apart, that, in passing by the doors to admit the tubs, one shall always be in an uncut portion of the tube, in order that the pressure shall remain constant when the piston is passing these doors. The lower part of the piston below the cage is made of one platform, and, if necessary, isolates the space occupied by the cage from the atmosphere below. A valve is placed in this platform which can be opened when men are riding to afford them the necessary air for breathing. It also carries a centrifugal parachute A, to prevent the too rapid descent of the cage in case of accident.

'The top plate of the piston carries a spring buffer B, which diminishes the shock when the valve C above is struck by the ascending piston. The piston is of simple construction. It can be made of wood protected with iron, packed with india-rubber at the edges, and covered with leather secured by bands of brass, or soft metal composed of a mixture of lead, zinc, tin, and antimony.

'The cage D is made in the usual way, and is constructed to hold nine tubs, one above the other, each containing about 20 cubic feet, the whole carrying about $4\frac{1}{2}$ tons of coal.

'The total weight of piston, cage, tubs, and coal is 26,450 lb., or about 12 tons, spread over the surface of the piston which has about 3,117 in. area. This gives a pressure, per square inch, of $\frac{26450}{3117} = 8\cdot4$ lb.

'When the pumping engine has reduced the air above the piston to $15 - 8\cdot4 = 6\cdot6$ lb. per square inch, the piston will commence its ascent with a speed dependent upon the speed of the exhausting cylinders. These exhausting cylinders are 108 in. diameter, or 63·6 square feet area, and nearly 10 ft. stroke, the two together exhausting 2,544 cubic feet per stroke, or 430 cubic feet per second, the engine making about 10 strokes per minute. The load will rise in the tube, which has a section of 21·5 square feet, with a speed of $\frac{430}{21\cdot5} = 20$ ft. per second.

'With machinery of this power it would take about 52 strokes to reduce the pressure above the piston to 6·6 lb. per square inch, and cause the cage to ascend, which, with a speed of about 200 ft. a minute, would occupy about $2\frac{1}{2}$ minutes. The extracting engine would continue to work during and after the ascent, and considerable advantage would arise from having a reservoir of convenient size from which the apparatus could extract the air during the descent of the piston.

'When the piston has to descend, the exhaustion from the tube is stopped, and its connection with the extracting engine is severed by means of doors or valves E, and the air is allowed to press upon the top of the cylinder by means of a regulator F, so that its pressure can be augmented till it reaches the point where it will cease to

sustain the weight of the cage without the coal, or till it reaches 20,450 lb., the weight of the cage and coal, less 10,080 lb, the weight of coal,

$$\frac{10370}{2117 \text{ area of piston}} = 5{\cdot}2 \text{ lb.}$$

'Valves and doors G are so arranged in the tube that the air is taken up from the return air course on the ascent of the piston and delivered outside the mine on its descent through H. Each descent, therefore, discharges a volume of foul air equal to 70,632 cubic feet in a tube 3,270 ft. long, which, of course, is replaced by fresh air descending into the mine.

'In order to get the tubs in and out, three double doors I I I are cut in the tube, both at top and bottom, and these correspond to three levels of the heapstead. The full tubs go out of the doors at one side, and the empty ones go in at the doors on the other.

'The whole of the nine tubs are changed by three movements of the cage. At the top, the first movement changes the first, fourth, and seventh tubs, the second movement changes the second, fifth, and eighth tubs, and the third movement changes the third, sixth, and ninth tubs. When the cage is at the bottom, the first movement changes the third, sixth, and ninth tubs, the second movement changes the second, fifth, and eighth tubs, and the third movement changes the first, fourth, and seventh tubs.

'In order to keep the cage steady and opposite to the doors for inserting and withdrawing the tubs, three double sets of stops are introduced, so that they can be thrust into the tube and withdrawn by means of one lever. These stops are numbered 1, 2 and 3, from top to bottom. When the cage is confined between the stops K 3 of the two sets, the tubs 1, 4 and 7 can be handled. When the cage is confined between the stops K 2 of each set, the tubs 2, 5 and 8 can be handled; and when the cage is confined by the stops K 1 of each set, the remaining tubs, 3, 6 and 9 can be handled. The top stops prevent the cage ascending, and the bottom stops prevent it from descending. The cage with its piston is then confined between the two sets of stops during the whole time the tubs are being changed, and is moved up and down with the greatest facility by means of equilibrium pipes and cocks as will be described.

'At the bottom of the pit the equilibrium pipe L goes from the bottom of the tube to a point sufficiently high to be above the piston during the whole time the tubs are being changed. When the cock M in this pipe is shut, the pressure of air in the bottom keeps the piston up against the top stops, and when the cock is open, and the main inlet and outlet valves N H shut, the air below is rarefied to the required point to allow the cage to fall on to the bottom stops. Between the top and bottom set of stops there is a play of about 1 in.

'At the top of the pit the tube has two pipes P and O, each provided with stop cocks P and Q. The first communicates with the atmosphere, and allows air to enter above the piston and causes it to descend. The second is in communication with the exhausting engine, and is arranged to increase at will the amount of vacuum, above the piston, to enable it to rise with the cages as each successive group of tubs is withdrawn.

'By means of special arrangements, either electrical or otherwise, the position of the cage in the tube, during its ascent and descent, is clearly indicated both to the men at bank and below.

'When the cage ascends, the doors I I I for changing the tubs are shut, together with the door on the pipe H, which communicates between the bottom of the tube and the top of the mine, and when the cage arrives at the top it is made to stop—first, by automatically shutting at U the communication with the exhausting engine at E; secondly, by lifting the valve S, and admitting the pressure of a certain quantity of air on the piston; and, thirdly, if the ascent still continues, by lifting the valve R at the top of the tube and allowing the free entry of the atmospheric pressure.

'When the cage descends it forces the air from the bottom of the tube through the escape valve H to the surface. When it comes near to where it has to stop it automatically closes the escape valve at T, and compresses the air in the bottom of the tube. The air can then be admitted from the under side of the piston into the partial vacuum above the piston by means of the equilibrium pipe L and cock M, so as to lower the cage upon the stops at will. The pressure above and below the piston is indicated by pressure gauges.

'All the movements of the cage are effected with the greatest ease. An accident could not possibly arise unless all the doors of the apparatus were open, which it is almost impossible could occur. In order, however, to effectually guard against any possibility of danger, a centrifugal parachute A is attached to the bottom of the cage.

This parachute is composed of circular hoops of steel nearly the diameter of the tube, furnished with wooden brakes where they approach the side of the tube, and are driven round by friction wheels fixed to the piston and running against the tube. The bands are free to move up or down upon their axes, and if their speed exceeds a certain limit the hoops will become oval and the wooden brakes will press against the sides of the tube, and by their friction prevent the too rapid descent of the cage.'

A comparison of the relative cost and advantages of the atmospheric system has been made by Mr. Blanchet. He says:—

'With a single pit of great depth, under all systems, there is an absolute necessity of having some duplicate means of getting at all parts of the shaft in case of accident occurring to the usual means of drawing. To effect this, there must either be a second auxiliary winding engine, which should have the same relation to the large winding engine as the old whims bore to the horse-gin, or the horse-gins to the crab engines. This auxiliary engine should in no case be dispensed with, as an accident might happen at any moment which might render it indispensable.

'Besides this auxiliary winding engine, which, in the present case, it has been decided to make of from 90 to 100-horse power, the atmospheric system requires an exhausting engine of about 600-horse power, with two cylinders 39½ inches diameter and about 6 feet 9 inches stroke, working two extracting cylinders of 108 inches diameter and 10 feet stroke. With regard to the pits at Hottinguer, the relative expense of three different modes of extracting coal may be considered:

'1st. With a duplicate pit and winding engine.

'2nd. With winding engine and a metal tube, instead of a second shaft.

'3rd. With tube and exhausting machinery.

'The expense of each system may be taken as follows:—

	System		
	1	2	3
Staying	£1,000	£1,000	£1,000
Second pit	20,000	—	—
Auxiliary engine . . .	2,000	2,000	2,000
Guides, &c.	2,000	2,000	2,000
Winding engine . . .	6,200	6,200	—
Fan	2,000	2,000	2,000
Tube	—	6,000	8,000
Ropes	4,000	4,000	—
Exhausting engines . . .	—	—	9,000
Foundation	—	—	—
	£37,200	£23,200	£24,000

'The figures show that the first system, with ropes and a new pit, is by far the most expensive; and the second system, which replaces the second pit by a simple tube, still using ropes, is not very much less costly than the third, which provides for a complete atmospheric apparatus and exhausting machinery. In fact, it requires an addition of only 800*l.*

'The system then appears to possess the following advantages, as far as regards the Hottinguer pit:—

'1st. It enables the pit to be worked five years sooner.

'2nd. It increases the ventilation and decreases the temperature of the mine.

'3rd. It admits of sinking to any depth.

'4th. It saves 2,000*l.* a year in ropes.

'5th. It enables more coal to be raised than with ropes.

'6th. It allows the whole inside of the pit, not actually occupied with the tube, to be free for repairs and for alterations, making new landing stages, &c.

'7th. It utilises more advantageously the power required to raise the coal.'

COAL TESTING *for Water.*—This subject was brought before the American Institute of Mining Engineers, on June 26, 1876, by Mr. J. Blodget Britton:—

Six different samples, each from a compact lump, were powdered and put in bottles. Portions of these were weighed and placed upon an ordinary water bath and dried for one hour; the average loss was 1·24. The same portions were then placed in a hot-air oven, and for two hours kept at a temperature of 265° Fahr., and, after cooling in a dry chamber, were again weighed; a further average loss of 1·22 occurred, making a total

of 2·46. The samples were immediately returned to the oven, and for two hours more were kept at a temperature of 530° Fahr., and *cooled* and weighed again, when no further loss was found, but an average gain of ·55 upon the previous weighing. The same portions were a third time placed in the oven, and for about ten minutes kept at the last-mentioned temperature, and then, while still hot, were poured into ¼-inch glass tubes, each with a bulb, and tested over a Bunsen burner at a temperature below a red heat, when more water vaporised and condensed in small clear globules at the cold parts of the tubes.

Fresh portions of the coal were then taken, and the total amount of water determined, and the average was found to be 3·04 or 1·80 more than was found at the temperature of the water bath, which was perhaps a little below 212° Fahr. and ·55 more than 235° Fahr.

Experiments were afterwards made by placing fresh portions of the coals within a bell glass over strong sulphuric acid for more than twenty-six hours, when the total average loss was found to be 1·91 or 1·13 below the amount of water actually present in the coal. Upon allowing some of these to remain in the open air for two hours, they were found to have nearly regained their original weights. Additional fresh portions were then weighed, and left exposed to the open air of the laboratory; the next day they were weighed again and found to have gained an average of 1·03. This gain proved to be due almost entirely to moisture absorbed. These experiments appear to prove that a process, analogous to that observed in the occlusion of gases, went on when the coal was exposed to moist air.

A sample of bituminous coal from Clearfield County, Pennsylvania, was treated in the same manner. Dried on the water bath for one hour it lost 1·69; dried in the hot-air oven for one hour at 250° Fahr. the loss was less, being 1·65, and for another hour at 280° Fahr. the loss remained nearly the same, 1·66. Being a third time returned to the oven and kept for about two hours at 580° Fahr., the loss was increased to 2·14. The coal was then tested in a bulb tube over a Bunsen burner at below a red heat, and the presence of water was distinctly detected. The actual amount of water in the sample was subsequently found to be 2·46 or ·77 more than the loss, at the temperature of the water bath, and ·32 more than at the temperature of 580° Fahr.

Many other experiments were made with gas coal from West Virginia, and with the true brown coals, or lignites, of Southern Arkansas, all of which tended to prove, 1st, that water exists in the several classes of coal in two conditions—i.e., combined and uncombined, but in these conditions not constant in relative proportions. 2nd. That some coals will and some will not, irrespective of the class to which they belong, when finely pulverised and left open to the air, gain in weight by taking oxygen, while at the same time they lose in weight by losing water and hydrocarbons, at temperatures varying between that water, and one that is sufficient for destructive distillation. 3rd. That all coals, when deprived by heat of any portion of their normal water, will, upon exposure to the open air at common temperatures, immediately begin to regain their loss. It therefore follows that correct weighing cannot be done with the material unenclosed. 4th. That the method of determining the water by merely finding the loss which the coal sustains by drying for one hour at 212° Fahr., or for any length of time, or at any temperature, whether over sulphuric acid or not, gives fallacious results.

COALS, VOLATILE MATTER IN, *and Coke and Ash.*—The following table was published in SAWARD'S *Coal Trade Journal* for November 29, 1876. The authority upon which it is founded is not given, which is to be regretted, as its value depends entirely upon the correctness with which the results have been obtained:—

No.	Name of Coal	Volatile Matter	Coke	Ash
1	Boghead. (*Scotland*)	68·4	31·6	22·8
2	New Brunswick Cannel	66·3	33·7	0·6
3	Kirkless. (*Lancashire*)	60·0	40·0	13·5
4	Capeldrae	54·5	45·5	10·6
5	Old Wemyss	52·5	47·5	15·1
6	Staffordshire Cannel	50·0	50·0	2·9
7	Lesmahago. (*Scotland*)	49·6	50·4	9·1
8	Knightswood	48·5	51·5	2·4
9	Arniston	45·5	54·5	4·2
10	Heather. (*Staffordshire*)	42·9	57·1	1·8
11	Ruabon Main. (*North Wales*)	41·5	58·5	1·0
12	Staveley. (*Derbyshire*)	40·9	59·1	2·7
13	Radstock. (*Somersetshire*)	38·3	61·7	2·5

No.	Name of Coal	Volatile Matter	Coke	Ash
14	Bunkinsop	38·0	62·0	5·1
15	Wigan. (*Lancashire*)	37·0	63·0	3·0
16	Mortombly. (*South Yorkshire*) . .	37·0	63·0	1·6
17	Elsecar. (*Do.*)	37·0	63·0	1·1
18	Ramsay. (*Newcastle*	36·8	63·2	6·6
19	Hartley, Hasting's. (*Durham*) . .	36·6	63·4	2·0
20	South Tyne. (*Do.*) . . .	36·3	63·7	3·9
21	Hartley-West. (*Do.*) . . .	35·8	64·2	4·7
22	Grigleston Cliff	35·6	64·4	1·0
23	Gosforth. (*North Riding, Yorkshire*) .	35·0	65·0	1·0
24	Soap-House Pit	35·0	65·0	0·8
25	Nailsea. (*Somersetshire*) . . .	34·9	65·1	3·0
26	Wallsend, Liverson's. (*Durham*) . .	34·9	65·1	4·9
27	Arley Main. (*Lancashire*) . . .	34·7	65·3	13·1
28	Lochgelly Cannel. (*Scotland*) . .	33·5	66·5	10·5
29	Woodthorpe. (*South Yorkshire*) . .	33·1	66·9	10·5
30	Pelton Main Cannel. (*Durham*) . .	31·5	68·5	9·4
31	Washington (*Do.*) . .	31·3	68·7	2·2
32	Pelaw Main	30·3	69·7	2·6
33	Pelton New. (*Durham*) . . .	30·2	69·8	1·8
34	Coal Pit Heat. (*Gloucestershire*) .	30·1	69·9	5·8
35	Garesfield	29·4	70·6	1·0
36	Dean's Primrose	29·3	70·7	2·4
37	Urpeth. (*Northumberland*) . . .	28·7	71·3	1·4
38	Pelton Main. (*Durham*) . . .	28·4	71·6	1·4
39	Penreth South	27·8	72·2	1·8
40	Cumberland.	25·6	74·0	1·4
41	(*South Wales*)	23·5	76·5	2·1

COAL WASHING *and Sorting.*—Max Evrard, in the *Bulletin de la Société d'Encouragement*, January 1875, describes a machine for the simultaneous washing and sorting of coal, as it is taken from the mine mixed with other material. 'This is accomplished by tipping the charge from the mine into a large hopper provided with a grating which arrests the largest pieces of coal; the remainder passes into a deep cylinder of boiler plate, partly filled with water, through which the coal descends to a perforated piston with which the cylinder is fitted. In sinking through the water the coal becomes arranged in layers in the order of the sizes of the pieces, the largest lying at the bottom; stones and small pieces of rock, being of greater specific gravity than the coal, sink more quickly, pass through the perforated piston, and are collected in a receptacle for that purpose. The boiler-plate cylinder dips for about half its length into a second cylinder, also of plate iron, and of about twice its diameter, their connection being rigid and steam-tight. This latter cylinder contains water to near five-sixths of its height, from which the former cylinder, which is open at the end, receives its supply.

'There is fitted into the upper surface of the large cylinder a steam pipe, which conveys steam, at a pressure of about 10 lb. per square inch, to the surface of the contained water, for the purpose of depressing the latter and thereby raising it in the smaller cylinder. The perforated piston which carries the load of coal is supported by a rod, fitted at its lower end with a small piston working in a hydraulic cylinder under pressure; this cylinder occupies the lower central portion of the smaller plate-iron cylinder, and is fixed to bearers fastened to the larger cylinder. The upper portion, a length of about three feet of the cylinder which carries the charge of coal, is made separate from, and capable of moving over, the lower portion upon horizontal guides fixed to the building in which the machine is contained, and along these guides it is pulled backwards and forwards by small pistons working in hydraulic cylinders. The operation of the machine is as follows:—Steam is first turned into the large cylinder, and the water therein depressed and forced upwards in the smaller cylinder to near the height of the joint between its lower fixed and its upper moveable portion. While the water is maintained at this height, the charge of coal is tipped into it from a small waggon. It descends on to the perforated piston, which is at its lowest position, the stones and larger pieces of coal reaching it first, and the charge thus becoming partly sorted. Steam is now turned off, and that left in the cylinder is condensed, forming a partial vacuum, which causes the water to pass from the smaller

cylinder through the coal and refill the large cylinder. Intermittent ascending and descending currents are thus directed through the charge of coal by turning the steam on or off as many times as may be necessary to clean and classify it. After the steam is turned off for the last time, the mass is allowed to stand for a period of from two to five minutes. By means of the hydraulic pressure cylinder, the entire mass is then raised sufficiently to allow of the upper layer of fine material and dirt to be directed into a trough by the horizontal movement of the upper portion of the cylinder. After the first operation, the moveable portion of the cylinder is returned, and the charge raised sufficiently to admit of the removal of another layer, or of the whole by the return motion of the cylinder. The trough through which the coal passes into small waggons is fitted with a grating to allow the water to drain from the coal into a receiver, by which it is conducted into a large settling tank, where it is cleared of mud and stones, and afterwards again used in the cleaning cylinder. Suitable tanks are provided, by which the proper supply of water is continually passed into the washing cylinder. The quantity of steam used per day in cleaning 200 tons of coal, including power used in supplying water under pressure for raising the washed coal, is about equivalent to 4-horse power; but as the process incurs no waste or loss, and as the coal is sorted, and a much larger proportion of it made available for the manufacture of coke, the inventor considers that the process may be carried on with a profit of 8*l.* per day from each set of such apparatus.'

The charge, which is about a yard high, has the form of a pile, in which you may clearly see the order in which the grains were deposited. The removal of each one of these various qualities is effected by means of a scraper in horizontal slices, the thickness of which varies according to the quality of the coal.

The following tables give two examples of gradation in the per-centages of ash applying to coals from the St. Etienne district:—

Heights of the Layers	Proportion of ash unwashed, 35 per cent.		
	Washed by the Classifier	Above the Sieve	Below the Sieve
Mètre	Per cent.	Per cent.	Per cent.
0·05	12	—	Dust
0·10	9	6	59
0·10	14·6	6·4	60
0·10	14	9	64
0·10	21	13·4	67
0·10	23	21·6	67·4
0·10	31	28	69
0·07	39	34	70
0·18	64	Shale	—
0·90			

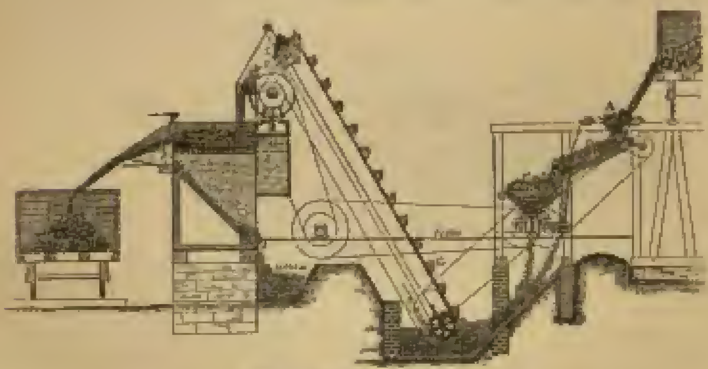
Heights of the Layers	Proportion of ash unwashed, 17 per cent.		
	Washed by the Classifier	Above the Sieve	Below the Sieve
Mètre	Per cent.	Per cent.	Per cent.
0·20	5	–	Dust
0·20	4	—	—
0·10	4	—	—
0·11	5	—	—
0·20	4·5	4	28
0·20	6·4	6	34
0·10	8	64	37
0·05	8·8	7	45
0·02	18·6	16	70
0·09	81	Shale	—
1·27			

In the article WASHING COAL, vol. iii. p. 1091, a description of M. BÉRARD'S machine is given, with two woodcuts illustrating it.

The American coal-washing machine is a modification of BÉRARD'S; there are, however, some simplifications in the arrangements which deserve attention. The apparatus, described by JOHN FULTON, was erected in 1873 near two lines of coke ovens. It was elaborated at West Point Foundry, on the Juniata river, by their engineer, Mr. F. RUMPF, the coal being the Broad Top coal used by the KEMBLE COAL AND IRON COMPANY.

The coal to be cleansed is cast into the hopper A (*fig.* 2300) from the railroad car by a side door and over an iron shoot, from whence it is diffused on the separator B, which is kept in agitation by the cam *a*. The large lumps, which will not pass through the 3-inch square openings in screen B, roll down to the screen platform C, where they are broken by a workman with a maul, and, falling through the grating, pass to the rolls D D. The smaller lumps pass through the 3-inch meshes in agitator screen B, when they are further divided by screen *b*. The portion of the coal which will not pass through the ⅝-inch holes in the latter screen pass directly to the rolls D D, whilst the very fine portion is carried under the rolls, down the shoot C, into the receiver F. The rolls D D have teeth or spurs set all over their circumference, each being about ¾ inch high by ½ inch square. Their arrangement is such that the spurs of one roll mesh into those of the other. One of the crushing rolls has its pillow blocks set in sides, with rubber ball spring *e*, so as to admit of a small horizontal movement to prevent the breaking of the teeth of the rolls by the passage of hard slates or rocks.

2300



COAL WASHING MACHINE.

After passing the rolls, the crushed coal falls into the receiver F, whence it is elevated by the chain of buckets, G, and delivered into the shoots H, through which it is carried into the separating pans, J, made of cast iron, with a copper plate on top of the grating, forming the bottom of the iron pan, which copper plate is filled with ⅛-inch holes, set close together. The pans are supplied with water conveyed into them by troughs, through which also the coal is carried. The action of the piston K, which moves with quick, short strokes (120 per minute), forces the water through the coal and slate in rapid pulsations, lifting the pure coal upwards and onwards with the movements of the water, until both are carried over the side of the pan at L, and thence over a grated shoot into the railroad car M, on the track in front of the washer. The impurities being heavier than coal, sink to the bottom of the pan, and are carried to its front interior angle, whence they are discharged by a valve, *d*, into the receiver N, from which they can be removed by a sliding bottom, *f*. The movement of the coal in the pans is about 20 inches per minute, giving a continuous overflow of washed coal into the railroad cars. This flow can be regulated by raising or lowering the front side of the wash-pan at L. The main portion of water is drained from the coal by a zone of fine copper-wire screen on a shoot, immediately under the discharge from the wash-pan at L. This water, charged with the very fine coal and dust, passes through *g*, and is conveyed by a trough, *h*, into a large tank alongside the washer, where the fine coal is permitted to settle, and is then shovelled into the railroad cars along with the coarser coal, and all carried and dumped into

the coking ovens without further handling. The washer, with three pans, is capable of cleaning $12\frac{1}{2}$ net tons of coal per hour. To supply one furnace with coke would require this apparatus to be run about 9 hours per day, or 18 hours to supply the two stacks when both are in blast.

The cost of machinery, gearing, motive power and independent steam pump, was $9,000; cost of erecting, $3,000; making total cost of apparatus, when ready for work, $12,000.

The cost of labour required at the washer in handling 1 ton of coal is given by William Lattimer, furnace superintendent, at 18 cents, to which must be added the interest on the washing plant at 10 per cent., $3\frac{1}{2}$ cents, making total cost of 1 net ton of washed coal, $21\frac{1}{2}$ cents. In addition to this, there is some waste of coal which should be taken into this calculation—(*a*) the very fine coal carried away suspended in the discharge water; and (*b*) the fine coal escaping with the slates and other impurities. The amount of fine coal in the former is 30 pounds per ton, and in the latter 20 pounds per ton, making the total waste of fine coal from these sources 50 pounds per ton, or $2\frac{1}{2}$ per cent. The slates, pyrites, and other impurities separated from the coal amount to 180 pounds per ton, or 9 per cent. The total impurities separated, and fine coal lost in the operation of washing amounts to 220 pounds per ton, or $11\frac{1}{2}$ per cent.

The cost of this 230 pounds of coal and slate is $13\frac{1}{2}$ cents, to which must be added the expense of the labour in washing and interest on apparatus, $21\frac{1}{2}$ cents, making the whole cost of labour and loss in washing 1 net ton of coal 35 cents.

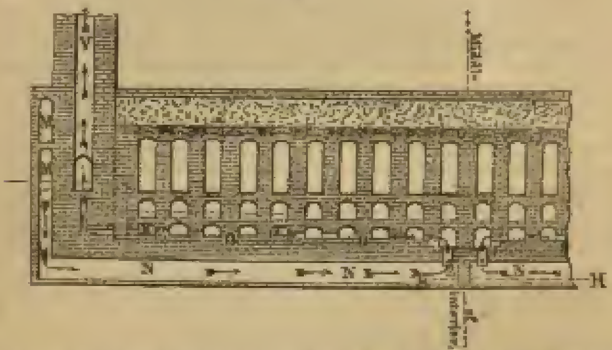
COAL-DUST COKE. Professor Green, in a paper on the 'Yorkshire Coal Field,' read before the Iron and Steel Institute at Leeds (1876), gives the following account of some ingenious arrangements made by the Silkstone and Dodworth Coal and Iron Company for making coke from the dust and refuse of their workings:—

'As the corves are raised from the pit—and they are raised in double lifts at the rate of four corves per minute from each shaft—the coal is tipped out on to a screen, the best household coal passing at once into the railway waggons. The largest "nuts," as they are termed, together with the "pea nuts" and "smudge," or dust, pass through screen No. 1 on to screen No. 2, the large nuts being delivered into waggons on the other side for use under steam boilers. The pea nuts and smudge fall through screen No. 2 into a hopper, which opens into a covered trough, in which is an Archimedean screw 60 ft. long. There are four of these screening apparatus delivering into the screw trough. The small coal is delivered at the far end of the screw into a pan, in which dips an elevator known as a Jacob's ladder, which is a series of buckets on an endless revolving band. These buckets carry up the small coal to a revolving screen or riddle, from which the pea nuts pass to a receiver, to be run out when full into waggons for use for steam purposes and gas making. The smudge is conveyed from the revolving riddle to two inclined troughs, which unite into one at a point some 200 ft. away. A constant and copious stream of water flows through these troughs, carrying the coal dust with it. Mixed with the coal dust, however, is a large percentage of metallic and other impurities, which must not be allowed to get into the coking ovens, or the coke would be spoilt. The flow of water and the inclination of the troughs are, however, so adjusted that the impurities of their own superior gravity settle in the trough, the lighter particles of pure coal being carried onward to a series of draining tanks, which commence at the 200 ft. distance. These draining tanks are formed of finely perforated metal plates, and in them the coal dust is deposited, the water draining off into a conduit beneath. These tanks are so arranged, that as each becomes full the stream of coal and water can be shut off and allowed to pass in turn to the others. The coal dust thus collected is removed from the tanks into corves, and taken to the coking ovens. The water, after passing all the draining tanks, still holds a considerable quantity of coal in suspension, and is, therefore, led away to settling ponds, whither also that which has drained from the tanks is conducted. At the head of the settling ponds are two compartments, 60 ft. long by 15 ft. wide and 3 ft. deep. These are used alternately, and as one becomes filled with coal dust, the water is turned into the other, and the full one is emptied, the deposit being conveyed to the coking ovens. The water from these compartments flows into two others in succession, each of which is 60 ft. long, 30 ft. wide, and 4 ft. and 6 ft. deep respectively. Here the last particles of coal settle, and are removed as the compartments become full, and are taken to the coking ovens. The water—now comparatively clean—flows away, still by gravitation, back near to the revolving riddle, and is there pumped up again to the troughs, after having completed a circuit of over 1,000 ft. The pumps employed for this purpose are one of Tangye's and one of Hayward Tyler's steam pumps. There are two blocks of coking ovens, one containing 50 and the other 30 ovens, which are placed in double rows, back to back. The ovens are charged with the coal dust at the top, and the waste gases are taken off

by a flue running centrally between the rows. At the end of the block of 30 ovens, which are of the Staffordshire arched type, is a row of 7 Lancashire double-flued boilers, each 30 ft. long, 7 ft. diameter, and with 2 ft. 9 in. flues. Two boilers in this series are heated by the waste gases from the coking ovens, and a third is being fitted for the same purpose. If the gases are not required for the boilers, they can be shut off and conducted to a large chimney shaft. These boilers supply steam to the winding and other engines.'

COKE OVEN. *The Coppée* has been already described in vol. i. p. 890; to that notice the reader is referred. In addition to what is there said, it appears that a further description is required, and we have reason for knowing that the additional woodcuts now given will be acceptable to manufacturers.

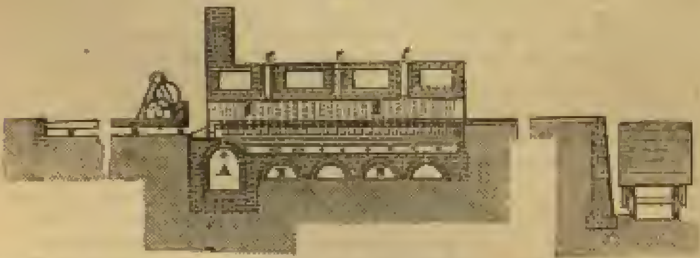
2301



The Coppée ovens are very highly thought of at the present time. Belgium possesses 624 of these in operation—several in the neighbourhood of Liège—and 192 others are being built. In Prussia, 1,306 are at work, and 138 are in course of erection. In France, 186 are in activity; and in England, 30 are at work at the Coppée Coke Company's works at Thorncliffe, and 30 more are being put up there.

As in the systems previously described, the Coppée ovens are placed together in groups of two and two. (See *fig.* 600, vol. i.) The flames from the two ovens of the same group pass through a series of openings, *a*, *a*, made in the arch, and circulate through suitable channels around the oven, then passing beneath the sole of the adjacent oven, enter by a vertical flue, *c*, into a common conduit, A, which first goes

2302



beneath the boilers and then leads to the chimney. The gases are burnt in the channels by two sets of numerous jets of warm air, the one set entering the oven at *d*, *d*, and the other entering the vertical flues at *e*, *e*; the admission of air is regulated in the former case by the slidebars, D, and in the latter case by the slidebars, F. Galleries under the brickwork are traversed by currents of cold air, which cool and preserve the construction. This air enters at M, M, and traverses four ordinary brick galleries, N, N; at the point z, in the centre of the structure, it ascends, entering the flues, O, O, to reach the two chimneys, V, V. To diminish the loss of heat, the tops of the ovens are covered with a bed of clay about 18 in. thick, on which bricks are laid.

The ordinary dimensions of an oven are:—Length, 9 m.; width, 0·45 m.; height,

1·20 m., for a coking of 24 hours. For a coking of 48 hours the width is 0·60 m., and the height 1·70 m.

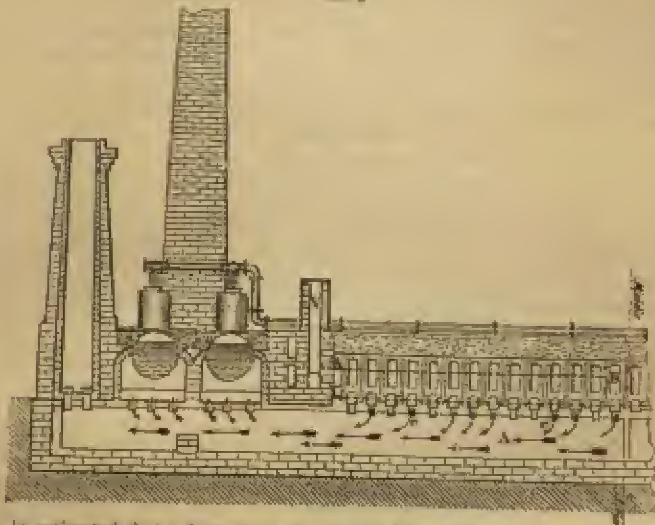
The ovens are quickly filled by three charging hoppers, *t*, *t*, *t*.

The characteristics of the Coppée furnaces are—

1. A small width, and an arrangement of channels especially suited for poor coals.
2. A combustion of gas by a double admission of air, which entirely suppresses the smoke.
3. The combination of all the hot gases in a large conduit beneath the ovens, and their utilisation for heating boilers.
4. Galleries for cooling and preserving the brickwork.

The additional figures now given will enable anyone to construct a series of these coke ovens with ease, since all the details are very clearly given.

2303



It is estimated that a furnace can heat a 3 or 4-horse boiler. This force is employed for breaking the coal, discharging the coke, &c. A furnace gives 2 tons of coke per 24 hours. The duty is high, and the quality of coke produced extremely good. A furnace, including foundation, to a depth of 1·85 m. below the ground level, costs 2,500 francs.

The following is the estimated cost for the construction of 26 ovens on this system, each oven to produce 2 tons of coke per 24 hours:—

	Francs
26 ovens, including 1·85 mètre of foundation beneath the sole of the ovens, at 2,500 francs per oven	65,000
Crusher and engine-house	7,000
Non-expansion 20-horse power steam engine	4,000
Feed-pump	1,400
1 crusher	3,400
Discharging apparatus, with boiler	8,200
Transmissions	3,600
Stones for engine foundations, &c.	1,000
Bands	1,600
6 small waggons	2,700
2 chains	4,000
Water reservoir	1,800
1 boiler, with fittings, chimney, &c.	14,000
Water-pipes and cocks	1,400
Steam-pipes	1,200
Discharge rails	3,000
Sundries	3,000
	116,200

The cost of the coke, taking 70 per cent. only as a basis, and the price of the coal delivered at the works at 30 francs per 1,000 kil., may be stated as follows:—

	Francs
Cost of manufacture, including loading waggons, tools, &c.	1·00
Annual charge of 15 per cent.	1·20
Expenses of management, office, &c.	0·30
1,430 kil. coal, at 30 francs per 1,000 kil.	42·90
Per ton of coke	45·40

The cost of washed coke would be 4 francs higher.

It has been urged that the Coppée ovens are too light on account of the side walls, which are only 0·33 m. thick, including a space of 0·09 m. for the passage of gas, but, from the experience obtained, we may safely assert that this criticism is entirely an unjust one.

Comparative experiments made in England with the elliptical beehive ovens and the Coppée furnaces give the following results, which we extract from the paper of Mr. Bainbridge:—

Summary showing Chief Points of Comparison between the Beehive and the Coppée Ovens.

	Common Oven	Coppée Oven
1. First cost per 2 tons of coke per day	116*l.* 7*s.*	100*l.*
2. Time burning	48 to 120 hours	24 hours.
3. Area occupied per ton of coke per day	1,218 sq. ft.	234 sq. ft.
4. Per cent. of yield { washed	45 per cent.	59 per cent.
4. Per cent. of yield { unwashed	54 "	68 "
5. Area of outside cooling surface per 2 tons of coke per day	1,062 sq. ft.	175 sq. ft.
6. Time occupied in emptying and refilling	60 minutes	8 minutes.
7. Units of heat in waste gases given off per oven per day	666,710	1,401,584
8. Labour charges (cost of coking) per ton	1*s.* 3*d.*	11*d.*

The arrangements for charging and emptying show also a marked improvement in the yield.

COKE, *the heating power of.* Karsten has determined the heating power of coke as follows:—

100 parts in volume of coke are equal to 250 parts of charcoal.
100 lb. " " " 80 lb. "

The weight of 1 cubic foot (Prussian), including the interstices of caked coke produced in ovens	= 22–25 lb. (Prussian)
The weight of 1 cubic foot (Prussian), including the interstices of caked coke produced in heaps	= 25–28 lb. "
The weight of 1 cubic foot (Prussian), including the interstices of sinter coke produced in heaps	= 33 "
The weight of 1 cubic foot (Prussian), including the interstices of sand coke produced in heaps	= 35 "
The weight of 1 cubic foot (Prussian), including the interstices of sand coke produced in tar ovens	= 35 "

Mr. Crookes (*Practical Treatise on Metallurgy*, vol. iii. p. 492) gives the following as results obtained in the smelting works of the Lower Hartz, showing the relation existing between charcoal and coke:—

100 cubic feet of charcoal	= 45 cubic feet of caked coke.
3 " of gas coke	= 3½ " "
60 bundles of brushwood	= 7½ " "
10 cubic feet of pine nuts	= 1½ " "
10 " of pine wood in billets	= 54 lb. of gas coke.
10 " " roots	= 72 lb. "
10 " " branches	= 65 lb. "
10 " of charcoal beech wood	= 96 lb. "

(The weights and measures are Hanoverian.)

The same authority informs us that the Society for Promoting Industry in Prussia has determined that 1 lb. of coke, which had been imperfectly charred in heaps, containing from 5 to 6 per cent. of water and from 2·4 to 4·3 per cent. of ash, converted from 7·15 to 7·55 lb. of water of 0° into steam of 110° to 115° Cent. One ton Prussian, equal to 7½ cubic feet of this coke, weighs 251 lb. According to FIFE (*Bgwkfd.* vii. 222), the mineral coal of Tarnout evaporates 6·66 times its own weight of water, and coke produces from this coal 7·4 times it own weight of water.

COKE, ANTHRACITE. Attention has recently been called to the manufacture of coke from anthracite. Before describing the modern process, it appears necessary to refer to the earlier processes for obtaining the same end. In 1850 Mr. JAMES PALMER BUDD, of Ystalyfera, patented a process of manufacturing coke by heating non-caking coal in intimate admixture with strongly caking coal. Every variety of non-caking coal, anthracite inclusive, is suitable for the process. The two kinds of coal are to be ground together in a pug-mill, or rolls may be employed for the purpose either with or without grooves. It is necessary that the non-caking coal, of whatever kind it may be, should be reduced to fine powder. This is not so essential for the caking coal.

Mr. BUDD's process was again patented no less than three times in 1856, by A. PERPIGNA (*Specification* No. 673), by Mr. R. A. BROOMAN (*Specification* No. 1,826), and by Mr. L. S. MAGNUS. But it does not appear that any of these processes were successful; certainly, if employed at all, they were soon abandoned.

In 1854 Mr. JOHN BETHELL obtained a patent for the manufacture of coke, by mixing non-caking coal with pitch, or pitch and bituminous coal. In 1858 another patent was obtained by Mr. BETHELL for making large coke of good quality, by heating in a common coke oven a mixture of *breeze* (see BREEZE and BREEZE OVEN, vol. i. p. 507) and coal tar, or coal tar pitch. In 1859 Dr. PERCY informs us in his *Metallurgy*, vol. i. p. 189, 1st edition, that he had an opportunity of witnessing BETHELL's process in operation at Llanelly, South Wales. The mixture employed consisted of crushed anthracite and coal-tar pitch, the anthracite being previously washed. In 1857 Mr. WILLIAM CORY patented (*Specification* No. 1,174) the manufacture of coke by heating the slack of free burning coal and anthracite with gas tar or pitch, in the proportions of one-fifth or one-tenth of the weight of the coal. CARL BUHRING, in 1857 (*Specification* No. 3,194), patented a process for making coke, which differed only from BETHELL's in claiming, in addition to the pitch, asphalt, sugar, wax, or any bitumen, resin, or gum, or any mixture of those substances. This patentee also claims any 'carbonised animal or vegetable material, such as coke, charcoal, boghead, ash, peat, coal, wood, bone, dried blood, or any such material, which, by the action of heat, may be carbonised.' In 1857 Mr. BIRNTRIER patented a similar process with the admixture of powdered limestone or other calcareous substances, and Mr. JAMES CHURCH, in 1860, patented a similar process, fixing the addition to be 25 lb. of slaked lime to 140 lb. of asphalt and 1 ton of coal (*Specification* No. 784).

At the meeting of the Iron and Steel Institute at Manchester, in September 1875, a paper was read by Mr. HACKNEY, from which the following information has been derived:—

'The high calorific power of anthracite, consisting as it does of nearly pure carbon, and the low percentage of sulphur and ash contained in most varieties, naturally render it of great value as a fuel in the cupola and blast furnace, while from its abundance in many districts, and the cheapness with which it may generally be worked, it should be at once the best and the cheapest fuel that could be used. The practical drawbacks to its use, which diminish its value and to a great extent restrict its employment, are the difficulty of utilising the slack, or small anthracite, of which a good deal is made in mining and handling, and in breaking the large pieces, and the tendency of many anthracites to split up into small particles if suddenly heated. In the blast furnace this decrepitation is especially injurious, as the fine dust is apt to form, together with the cinder, pasty masses that can neither be melted nor burned away, and may choke the furnace up or seriously derange its working. These difficulties in the way of using anthracite generally, in its natural or raw state, have led to many attempts to make it into a serviceable coke, by coking it in admixture with a greater or less proportion of binding coal, pitch, or other bituminous substances. None of these attempts, until very recently, appear, however, to have been commercially successful; none, at least, of those made in South Wales have been carried out largely or continuously; as, though coherent coke was made, it was friable and of inferior quality.'

Anthracite coke is now (1876) being made by Messrs. PENROSE and RICHARDS, of Swansea, from whom most of the following information has been obtained.

The materials used are any quality of anthracite or semi-anthracite, if free from

shale or stones, good bituminous or binding coal and pitch, in the following proportions:—

Anthracite	60
Bituminous coal	35
Pitch	5
	100

The bituminous coal used in making this coke is that from Tyisha Colliery, near Swansea. The materials are passed together through a Carr's disintegrator, to crush and mix them; the proportions in which they are mixed being regulated by supplying the feeding hopper of the disintegrator by three elevators, one carrying up each constituent, and each provided with buckets of such size and number as to bring up the relative quantity required. The ovens used are of the oblong shape generally employed in South Wales—15 ft. long by 15 ft. 7 in. wide at the back, and 6 ft. 2 in. in front, and 4 ft. 4 in. high to the under side of the arch. Each oven is charged, through a hole in the roof, with about four tons of this crushed mixture; this is levelled by a rabble put in through the door at the end; and a small quantity of bituminous coal, sufficient to form a layer about two inches thick, is thrown in and spread uniformly over the surface. The oven is then lighted by throwing a few shovelfuls of hot embers on the top of the charge, immediately inside of the door, and the coking is managed as in working an ordinary charge of bituminous coal. The object of covering the charge with a layer of bituminous coal is to prevent the burning away of the pitch, and its use appears to be essential for the production of a hard and strong coke. Ordinary slack of the same quality as that in the mixture is used for the covering; this is mostly very small, but is not specially crushed. Rather more than two charges per week are made in each oven. The coke is watered in the oven, and is then drawn out in one mass by a chain and hand winch. The yield of coke is 80 per cent. of the weight of the charge. The coke is steel grey in colour, and very much harder than the anthracite from which it is made; so hard, indeed, that it scratches glass with comparative ease. In a common fire, or under the action of a blast, it burns away without showing any tendency to crumble or decrepitate. It is about 23 per cent. heavier than the best coke made from Welsh bituminous coal, so that in sending a cargo abroad recently, a vessel that could not carry more than 240 tons of ordinary coke was able to take in as much as 310 tons of anthracite coke. Another valuable consequence of the dense compact character of the coke, in addition to the saving in cost of carriage, is, that even if soaked in water it takes up very little —only from 1·5 to 2 per cent.—of its weight, while many kinds of ordinary coke absorb readily 10 per cent. or more. The coke is harder and more dense, the finer the materials are crushed, and the more intimately they are mixed. In practical use, both in the cupola and in the blast furnace, the coke, so far as it has been tried, has given remarkably good results. These are probably due in part to its hardness and density, or rather to the high temperature required to set it on fire, which brings the zone of combustion closer to the tuyeres, and diminishes the waste of fuel in the upper part of the furnace caused by the transformation of CO^2 into CO; and in part to its freedom from water, and the small amount of ash that it contains. In a small foundry cupola, in which 1 lb. of good Welsh coke—that from Bryndu, near Bridgend—melts 10 lb. of iron, 1 lb. of anthracite coke melts 16 lb., and the metal is hotter when tapped out; and in a trial carried out at Messrs. Tangye's works, near Birmingham, anthracite coke melted well with 25 per cent. more burden than that placed on ordinary coke, and would probably have done more, but the managers were unwilling to run any risk of deranging the working of the cupola, and did not push the experiment further. In a trial made in one of the blast furnaces at Landore, working on *Spiegeleisen*, the burden in using anthracite coke was increased 28½ per cent., and the economy might probably have been raised to 30 per cent. or more, but the stock of coke in hand was not sufficient to admit of carrying on the experiment. The Landore Company are, however, so satisfied of the value of the coke, that they have nearly completed preparations for making it in all their ovens, and using nothing else in their two blast furnaces. The cost of anthracite coke is about the same as that of the best ordinary coke made in the district. Anthracite, in Wales, is about 2s. a ton cheaper than bituminous coal—an economy in one constituent that balances the extra cost of the pitch; and in making best ordinary coke, the coal used is ground, at a cost of about 6d. a ton, just as in the case of coke from anthracite. The yield of 80 per cent. in coking anthracite, against 70 per cent. or less in coking bituminous coal, is again in favour of the former. The cost of the crushing and mixing arrangements, to grind 1,000 tons a day, is estimated by the inventors at from 2,000*l*. to 2,500*l*. This would include a 6 ft. 3 in. disintegrator, with driving power, elevators, and shed.

The process has been carried on near Swansea for about nine months, and though it was suspended for some time during last winter on account of the colliers' strike, between 2,000 and 3,000 tons have in all been made to this time (1876). The field for the application of any practical method of utilising small anthracite is very great; the quantity available in Wales, and in America, is almost unlimited, and very much of that raised is now unsaleable, merely because it is too small to be used. In Pennsylvania, according to Mr. Bell, from one-fifth to one-half of the material brought to the surface in the anthracite collieries is thus thrown aside, partly shale and stones, but chiefly small and dust coal, perfectly clean and bright.

Dulait System. (Vol. i. p. 885.)—In addition to the description of processes given in the first volume, it becomes necessary to give some special account of the Dulait system, which has been extensively used on the Continent.

In a group of ovens on the Dulait system (*figs.* 2304, 2305), the ovens are placed in pairs—one oven heating the adjoining one. It allows of the extinction at will of any portion of a group of ovens, while the remainder are kept in full operation. The flames issuing at a descend directly below the sole, by the chimney, *a*, circulate in the flues, *b b*, at the end of which each current subdivides in the channels, *c c c c*. The flames then ascend at *d d d d*, where each current makes a zigzag similar to *c c c*, before reaching the chimney, *f*. It will thus be seen that each chimney is divided into four compartments. Their length is 7 mètres; width, 0·75 mètre generally, but is variable according to the quality of the coal; the height to the base of the arch is 1·15 mètres; the height of the arch 0·10 mètre; and the incline of the sole towards

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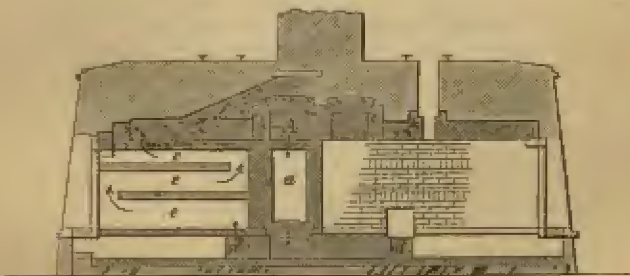

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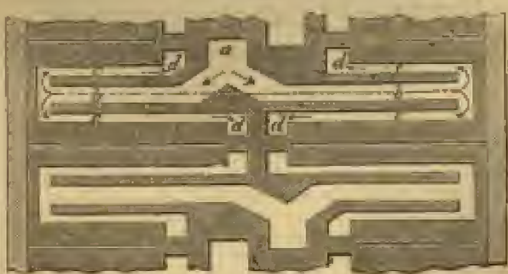

the discharging level is 0·02 m. per mètre. In order to avoid waste of heat as well as the action of the winds and of the penetration of air, these ovens are furnished with double doors. The interior doors are of cast iron, and formed of two parts; the lower part, 0·70 mètre in height, opens for the discharge of the coke and closes immediately after; the upper part, 0·48 mètre in height, opens to allow of the insertion of the rabble for regulating the charge. The outside doors are level with the face of the structure, at a distance of 0·30 m. from the preceding ones, and are of sheet iron, of a thickness of 0·005 mètre. The disposition of these doors reduces the space really occupied by the coal in the furnace to a length of 6 mètres. Carbonisation in a close vessel is one of the principles on which the Dulait system is based, in consequence of which all the doors are carefully closed all round with clay. The hoppers for charging the ovens are also closed both at the top and bottom, the lower part being shut in by

a cast-iron slab cemented with clay on the brickwork, and the upper portion has a cover, the edges of which rest in a channel filled with powdered coal.

The carbonisation in a close vessel gives a maximum yield. But if air is excluded from the oven and does not consume a portion of the coal during combustion, we, however, must be able to obtain the heat necessary for the coking operation. M. Dulait, following out the idea already put forward in England by Mr. Cox, has attained the desired result by burning the gases in the circulating flues by means of the introduction into these flues of numerous jets of heated air. In order to provide for this, one of the walls of the flues through which the gases pass is built of two rows of hollow bricks, superposed (*fig.* 2306). These bricks have a section of 0·10 mètre by 0·12 mètre. They are pierced by a longitudinal hole 0·05 mètre in diameter, in such a manner that, by their juxtaposition, they form two superimposed channels as long as the whole flue. The lower channel is open at the front of the oven and closed at the other extremity, where it rises in order to communicate with the upper parallel channel. This is pierced by holes 0·008 mètre in diameter, placed at a distance of 1 decimètre from each other, and opening into the flue in which the combustible gases are circulating. By this arrangement the external air taken in by the draught penetrates into the lower channel, where it gets heated, and, reaching the upper passage, is projected across the stream divided into innumerable streamlets, which increase

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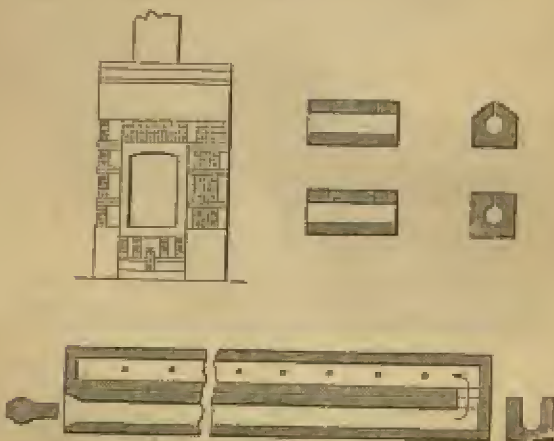

the surface of contact, thus effecting perfect combustion of the gases, and producing the highest possible degree of temperature, so that the gases are in this way fully utilised. As a result, if the coal is of the right quality, the combustible gases are produced in sufficient quantity to admit of the complete distillation of the coal, and the heating of the whole of the apparatus in a regular and permanent manner.

This system does away with the necessity for providing openings for draught, or reduces it to a theoretical absence of draught, limited only by the care with which the clay has been applied to the doors.

Coke prepared under Pressure.—Mr. E. T. Cox, State Geologist, Indiana, and his assistant Dr. G. M. Levette, have been making a series of experiments to obtain a definite idea of the effects of pressure on the coking of coals.

Powdered coal was placed in a retort, and after luting the rim with a paste of fire-clay the cover was attached with a screw clamp. The retort was placed in an iron cylinder lined with fire-clay and maintained at a bright red heat for about an hour.

The coals used were from the districts named in the following table, and the results show first, the quantity of coke obtained by analysis, and then the percentage of coke obtained under the different degrees of pressure named.

These experiments go to show that the temperature at which the fixed carbon of the coal will melt, depends upon the nature and arrangements of the protean compounds which enter into its composition. The fixed carbon of the Pittsburg coal melts at a comparatively low temperature, and under the increase of heat, induced by pressure, it becomes fluid enough to expand into a mere bubble.

	Proximate analysis	Iron retort. No mercury	Iron retort. 3 in. of mercury	Iron retort. 6 in. of mercury	Iron retort. 12 in. of mercury
From	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Sullivan County	62·40	59·10	62·00	62·80	59·40
Pittsburg . .	57·90	65·05	65·00	65·10	66·10
Clay County .	58·30	62·20	61·75	62·60	63·40
" .	57·50	58·50	60·40	58·50	60·25
Knox County .	52·50	54·25	54·00	54·30	56·50
" .	55·50	56·10	56·40	57·05	56·15

To make a dense coke of such a coal, instead of using pressure, the operation of coking should be conducted in ovens, where the gas could be removed by exhaustion as fast as formed. This is done at the gas works; here the retorts are exhausted of gas as fast as it is formed, and the coke made in this way is very hard and strong. Coal like that from Sullivan county gives a better coke when pressure is applied, and the block coal is almost worthless for coke unless it is distilled under a very great pressure, since it takes a high temperature to fuse and cement its carbon particles together. These experiments also assist in explaining why some of the caking coals will not answer, in the raw state, as fuel for smelting iron in the blast-furnace, and why the block coal is used advantageously for that purpose. The closed top blast-furnace, with its gas flues, may be very properly substituted for the retort in coking coal, with this advantage for the former; the coke is subjected to the additional pressure produced by the superimposed ore and limestone. In another experiment it was found that the density and strength of the coke is materially increased by covering it with 1 in. of sand and permitting the gas to escape without additional pressure.

These experiments show that the dry burning or block coal of Indiana, contrary to the commonly received opinion, can be made, under proper treatment, into a remarkably strong and dense coke; one of the essential conditions being a suitable degree of pressure to ensure heat enough to fuse its refractory carbon into a homogeneous mass. Furthermore, the above mode of testing coal is calculated to give a far better idea of its value as a fuel than it is possible to obtain by the ordinary proximate analysis. It enables us to know at once under what conditions a coal must be distilled in order to fuse its carbon into a strong and dense coke. It teaches us, also, how a bituminous coal, when subjected to heat under pressure, may be converted into anthracite and not coke.

It is Mr. Cox's intention to pursue still further the investigation of coking coal under pressure, and he proposes to arrange an apparatus for that purpose which will secure a pressure at least equal to one atmosphere.

Coke, Peculiar forms of.—Mr. E. Tulley Newton, of the Geological Survey, has drawn attention to some peculiar forms of coke, which he has examined microscopically. This gentleman communicated the results of his observations to the *Philosophical Magazine*, January 1876, from which the following description has been abridged:—

'The specimens examined were of two kinds, both obtained from a coke oven, and are so unlike each other that there can be no doubt that they had been formed in an entirely different manner. One of them had a silvery metallic lustre, and was usually attached to some object, either as a flat expansion, or in masses of feather-like branches (*figs.* 2307 to 2310), having much the appearance of minute stalactites. The surface, which is sometimes smooth, mostly appears to consist of a number of minute globules or bubbles closely packed together. When any considerable thickness is formed it becomes very hard and dense.

'The bubble-like appearance of some specimens might lead one to suppose that they were formed by the bubbling of the semifluid hydrocarbons, in a manner similar to that which may be often seen when ordinary coal is burnt in a grate; but the fact that objects, as tobacco pipes, become coated with this coke, shows conclusively that this cannot be the case. And, again, the bubbling process produces light vesicular masses, while the kind of which we speak is very dense. It seems most probable that, when the gaseous hydrocarbons evolved in the process of distillation become more highly heated, they are decomposed and a deposition of carbon takes place, as described by Dr. Percy in his volume *On Fuel*, 1875, p. 419. The Chinese give some of their common earthenware a coating of carbon of this kind, which gives it a metallic lustre. Mr. C. Tookey, formerly of the Japan Mint, tells me that the

Japanese use, for the roofs of their houses, tiles which have been coated with carbon in a manner similar to this.

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'The second kind is that which is commonly known as hair-like coke, and is interesting inasmuch as it presents, when examined with the microscope, a great variety of curious forms. In most instances these 'hairs' are of a dull black; but sometimes they have a silvery appearance. The forms assumed are occasionally of such a character that it is difficult to divest one's mind of the idea that they are organic structures.

'The "hairs" are not uniform in thickness, but vary from the $\frac{1}{1000}$th of an inch in diameter, or even less, to perhaps the $\frac{1}{100}$th of an inch, or even more. Some are straight or only slightly curved; others are bent, distorted, and knotted in a variety of ways. The finer "hairs" are mostly smooth and cylindrical; but some have a granular appearance; and occasionally the granules are so large in proportion to the size of the "hair" as to present an irregular knotted appearance, like those forming the tuft of specimens. On many of the larger "hairs" more or less distinct transverse markings may be seen; and these often become definite constrictions arranged in a very regular manner—so much so that they closely resemble, on a small scale, the moniliform stems of the stone lilies or Encrinites, which are so well known in the Wenlock and carboniferous limestones. Forms like these are not at all rare. Each segment appears to consist of a bundle of tubes or rods close together where they spring from the segment below, but gradually spreading out as they pass upwards, and terminating abruptly at the rounded surface which forms the top of the segment (*fig.* 2309). No definite openings could be seen upon the upper rounded surface; but it appeared slightly granular. *Fig.* 2310 represents a form of which there are many varieties, all exhibiting a series of regular ridges passing obliquely outwards from a middle line, which is either a groove, a ridge, or an irregular ridge broken up into segments, as in the figure. This specimen is not cylindrical, but flattened, and has the appearance of being two "hairs" placed side by side and joined to each other at intervals.

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2310

'With regard to the internal structure of this hair-like coke, some of the fibres when broken open appear vesicular, while others are solid and have much the aspect of a piece of charcoal. The solid "hairs" must, I think, have been formed in the first place as threads of semifluid carbonaceous material, and subsequently decomposed by being further heated. There is little room for doubting that the vesicular kind of "hairs" have been produced by a process of bubbling, caused by gases forcing their way through the semifluid carbonaceous matters. It is not difficult to imagine that such simple forms as those represented may have been formed in either of these ways, or to understand how a series of bubbles formed rapidly one beyond another might produce the moniliform character, although one would scarcely have expected it to be so regular; but it is not easy to imagine how either process could have produced the regular oblique markings of some of the bundles of tubes seen in the specimen.'

COBALT in South Africa.—Cobalt ores have been found and are being worked to some small extent by an English company in the Transvaal.

This metal, according to Mr. E. J. Dunn, is found near Oliphant River, South Africa. He says in his *Further Notes on the Diamond Fields of South Africa* (*Geological Society*, June 1876): 'It does not occur in lodes, but in small threads and lenticular veins running parallel to a dyke of fine-grained dolerite; the widest vein of ore was 3 inches thick. More than 100 tons of ore have been sent to London.

Cobalt, Nitrate of.—A test for Alcohol. See Alcohol.

COCA or **CUCA.** (Vol. i. p. 875.)—The *Erythroxylon Coca* (literally *red wood*) is extensively cultivated by the inhabitants of the countries on the Pacific coasts of South America. The plant is, technically, a shrub, growing from 6 ft. to 8 ft. in height, and resembling in appearance a blackthorn bush, especially when in bloom. The leaves are oval, tapering towards both extremities, the upper surface dark green, the lower paler, and marked on each side of the midrib with a vein which runs parallel with the margin. The foliage resembles the strawberry tree of Spain, but the leaves are much thinner. The plants thrive best in the clearances amid the elevated forests of the Andes, where frosts are unknown, and the heat, which is never extreme, is tempered by frequent showers of rain. As many as three gatherings can be made in a year, but care is taken to remove the leaves singly by nipping them off without damaging the axillary buds. The leaves, when gathered, are dried as rapidly as possible in the sun, and in the process emit a powerful odour, which produces headache and nausea in those unaccustomed to it. This odour, however, passes away with the moisture of the green leaves, and by the time they are ready for packing they possess a not unpleasant odour, suggestive of a strong rough tea. Good samples of coca should have the leaves flat, not rolled or twisted, and with only a small percentage broken, when freshly opened; but, as they are thin and crisp, handling necessarily fractures many. The upper surface should be a deep green, the under a paler or grey green; in inferior and old samples the majority of the leaves are brown, only a few having the dark green tinge, which would seem to be the index of value, for it is certain that the brown leaves have lost much of their flavour, and fail to produce that sense of 'warmth' in the mouth which is the not unpleasant result of chewing the green leaves. The Peruvians declare that in a few months the leaves lose much of their virtue, and when taken to the coast towns or exported are worthless in a year; but, however much the leaves may deteriorate by lapse of time, it is certain that if carefully packed they retain their power of stimulating for many years. There are about 70 known species of Erythroxylon, the best known of which are *E. suberosum*, the bark and wood of which supplies a reddish-brown dye, and the *E. areolatum*, the young shoots of which possess stimulating properties, while the bark is a tonic, and the expressed juice of the leaves is said to be used externally in liver complaints. Nearly all the species possess either stimulating or tonic properties, and several of them may be made to yield a reddish dye, though it is practically of little value.

The best accounts of the virtues of coca will be found in the *Journal of the Botanical Society of Edinburgh*, in a paper read before the Society by Dr. R. Christison.

His first experiments were made in 1870 with leaves that must have been about seven years old, but had been well cured and well preserved by sprinkling a little quicklime amongst them. Two of his students having first tired themselves by a long walk of 16 miles, took an infusion of 2 drms. of coca with 5 grs. of carbonate of soda. The students, who were not only tired but hungry, having eaten nothing since breakfast, lost all feeling of both hunger and fatigue soon after drinking the coca, and went for a walk for an hour, and returning made an excellent dinner, were alert during the evening, and slept soundly at night. Last year (1876) Dr. Christison, having obtained a further supply, ten students made a trial of it, and after long walks, some of 20 miles without food, all found hunger to cease for a time, and four experienced complete relief from the feeling of fatigue. Last May Dr. Christison walked 15 miles

in four stages without food of any kind, and was so thoroughly tired that he felt a difficulty in maintaining his pace during the last stage—in fact, he was effectually fatigued. A few days later he walked 16 miles in three stages, and, having completed 10, felt quite fagged enough to look forward to the remaining six with reluctance. During the rest he chewed 60 grains of coca, but did not observe any sensible effect until he got out of doors, and put on his usual pace, when he was surprised to find that all sense of weariness from the previous 10 miles had vanished, although he had only rested 45 minutes after completing the second stage of the 10 miles. He finished the 6 miles at a four-mile pace, and went up to his dressing-room two steps at a time, without any sense of fatigue or other uneasiness whatsoever. During the walk 40 grs. more coca were chewed, bringing the quantity up to two drms. Neither hunger, nor thirst, nor fatigue were felt, although Dr. Christison had abstained from food for nine hours, and had performed a hard day's work for a man of his years. He made an excellent dinner, felt free from drowsiness, and slept soundly. In the autumn he made the ascent of Ben Voirlich, 2,900 ft. above the roadway, and chewed 40 grs. of coca-leaves as his luncheon. He made the descent with ease—chewing 20 grs. more—was neither weary, nor hungry, nor thirsty, and could have easily walked home if it had been necessary. This experiment was afterwards repeated with similar results. The facts detailed speak for themselves. When taken in excess, coca produces an intoxication resembling that of opium. Spruce says that an Indian with a chew of 'spadic' in his cheek will go two or three days without food, and without feeling any desire for sleep.

COCHINEAL. (Vol. i. p. 575.) Sulphate of barytes and China clay have been used to adulterate and give weight to cochineal.

Cochineal.—The crop in the Canary Islands is no longer remunerative, prices having fallen from 11 or 12 francs per pound Spanish of 460 grammes in 1848 to 2½ francs at present date (1875). The total exports of the Canaries in 1873–4 were 2,310,318 kilos., of which 1,452,030 were sent to England.

Adulteration of.—Cochineal is sometimes adulterated with sulphate of zinc. The cochineal is immersed in a solution of sulphate of zinc, and then in an alkali. Oxide of zinc gives the pulverulent character of the genuine grain, and the weight is increased.

Cochineal, Ammoniacal.—For dyeing 5 lb. of silk take 5 or 6 gallons of water, and prepare the bath with 1½ oz. tartaric acid, or ¾ oz. sulphuric acid, and ½ gallon of ammoniacal cochineal at 2½ or 4 Twad. (Cochineal rubbed up with ammonia and dissolved in soft water). We find in the directions given to the silk dyer, 'The silk may be weighted to the extent of 10 or 15 per cent. by adding dissolved sugar or honey to the dye bath.'

Cochineal is used in colouring wine. For its detection, see Wines.

Cochineal, granilla, and dust were *imported* in the years named as follows:—

	1873	1874	1875	1876
Cwts.	42,263	39,393	40,941	29,379
Value	£635,091	£478,761	£492,976	£332,461

and of our import the cochineal exported in 1876 was

17,105 cwts. Value £187,308

COFFEE. According to Prussian statistical returns, the production of coffee has increased in 40 years from 95,000 to 425,000 tons. The relative consumption per head of the population in different European countries is as follows:—

Belgium	8·82 lb. per annum
Holland	[illegible] " "
Switzerland	6·76 " "
Denmark	4·83 " "
Germany	4·55 " "
Sweden	3·00 " "
France	[illegible] " "
Austria	1·40 " "
Italy	0·94 " "
Great Britain	0·83 " "
Russia	0·18 " "

COLLIERY EXPLOSIONS—1710 TO 1875.

Summary of the principal Colliery Explosions, &c., since the Year 1710, and the Number of Miners Killed.

Year	Date	Name of Colliery	No. lost
1710		Bensham	70
1743	January 18	North Biddick	17
1755	May 2	Gonne Lane, Worsbro'	2
1756	August 11	Chaters' Haugh	4
1757	June 16	Ravensworth	16
1760	June 15	Hartley	5
1761	December 1	Walker	8
1766	April 2	Walker	10
1766	April 16	South Biddick	27
1766	August 22	Lambton	6
1767	March 27	Fatfield	39
1773	December 6	North Biddick	10
1778	December 3	Chaters' Haugh	24
1783	May 17	Fauld Pit, Gateshead	4
1784	November 6	Wallsend	3
1785	December 4	Wallsend	6
1786	April	Wallsend	7
1793	December 27	Hope Pit, Sheriff Hill	—
1794	June 9	Picktree	30
1794	June 11	Harraton	28
1794	December 21	Hope Pit, Sheriff Hill	—
1796	April 24	Benwell	11
1796	February 12	Washington	17
1796	September 8	Slaty Ford	6
1797	April 11	Lumbley	31
1797	April 19	Rothwell Haigh	13
1803	September 25	Wallsend	13
1805	October 21	Hebburn	35
1805	November 29	Oxclose	38
1806	March 28	Killingworth	10
1808	November 29	Harraton	4
1809	June 30	East Ardsley	10
1809	September 14	Killingworth	12
1812	May 25	Felling	92
1812	October 10	Herrington Mill Pit, Penshaw	24
1813	July 17	Collingwood Main	8
1813	September 28	Hall Pit, Fatfield	32
1813	December 24	Felling	22
1814	April 5	Howdon	4
1814	April 12	Hebburn	11
1814	September 9	Leafield	4
1815	June 2	New Bottle, Success Pit	57
1815	June 27	Sheriff Hill	11
1815		Heaton, Newcastle	75
1817	June 30	Harraton, Nova Scotia	46
1817	September 25	Jarrow	6
1817	December 18	Plain Pit, Rainton	27
1819	July 19	Sheriff Hill	35
1819	October 9	George Pit, Lumbley	13
1821	October 10	Nesham	6
1821	October 23	Wallsend, Russell's	52
1821	October 23	Felling	6
1822	July	Coal Pit, near Sheffield	5
1823	November 3	Plain Pit, Rainton	59
1824	October 26	George Pit, Lumbley	14
1824	November 18	Dorothy Pit, Newbottle	11
1825	January 12	Gosporth, Middleton, Leeds	25
1825	July 3	Judy Pit, Fatfield	11
1825	October 5	Hebburn	4

Year	Date	Name of Colliery	No. lost
1826	January 17 . .	Jarrow	34
1826	May 30 . . .	Townley	38
1826	September 5 . .	Heworth	5
1828	May 15 . . .	Jarrow	8
1828	September 1 . .	Houghton-le-Spring . . .	7
1828	November 20 . .	E. Pit, Washington . .	14
1830	August 3 . .	Jarrow, Bensham seam . . .	40
1831	September 20 . .	Willington	7
1832	June 15 . . .	Newbottle	12
1833	May 6 . . .	Springwell	47
1833	May 30 . . .	Lindley Top, Huddersfield . . .	6
1835	February 3 . .	Thorns Pit, Hetton	22
1835	June 18 . . .	Wallsend	102
1835	November 19 . .	Burdon Main . . .	11
1836	January 27 . .	High Heworth . . .	4
1836	January 28 . .	Hetton Colliery . . .	20
1836	July 19 . . .	B. Pit, Hebburn . . .	3
1836	December 13 . .	Bag Pit, Wakefield, Yorkshire	—
1837	December 6 . .	Springwell	30
1838	February 16 . .	Robin Hood, Yorkshire . .	—
1838	December 19 . .	Wallsend	11
1839	June 28 . . .	St. Hilda	51
1840	January 24 . .	Rothwell Haigh Pit . . .	7
1841	April 19 . .	Willington	32
1841	August 5 . .	Thornley	9
1841	November 22 . .	Mount Osborne, No. 1, Barnsley	15
1843	April 5 . . .	King Pit	28
1843	. . . .	South Hetton	3
1844	September 28 . .	Haswell	95
1845	August 21 . .	Jarrow	39
1847	March 5 . .	Ardsley Oaks, Barnsley . . .	73
1847	May 17 . . .	Beeston Main, Leeds . . .	9
1849	January 24 . .	Darley Main, Worsbro', Barnsley . .	75
1849	. . . .	South Wales	52
1850	. . . .	South Wales	13
1850	November 11 . .	Houghton	26
1850	December 15 . .	Rawmarsh	51
1851	March 15 . .	Nitshill, Scotland	61
1851	August 19 . .	Washington	28
1851	October 31 . .	Killingworth	9
1851	December 20 . .	Warren Vale Colliery, Rotherham . .	52
1852	May . . .	Hebburn	23
1852	. . . .	South Wales	65
1852	December 22 . .	Elsecar, Low Hemingfield, Barnsley .	6
1853	March 24	Ince Hall, Arley Mine, Wigan . .	58
1853	April 26 . .	Old Park Colliery, Oldham . . .	11
1853	July 1 . . .	Bent Grange Colliery, Oldham . .	20
1854	August 22 . .	Hemingfield, Barnsley	5
1855	. . . .	Middle Duffryn	68
1856	. . . .	Cymmer Colliery	114
1857	February 19 . .	Lundhill, Barnsley	189
1858	. . . .	South Wales	19
1858	. . . .	South Wales	12
1860	January 15 . .	Charlesworth's Colliery, Higham . .	12
1860	March 2 . . .	Burradon Colliery, Newcastle . .	74
1860	. . . .	South Wales	14
1860	December 7 . .	Risca, South Wales	130
1860	December 20 . .	Hetton	22
1861	March 6 . . .	Lyneyshaw Pit, Worsley, Lancashire .	—
1861	. . . .	South Wales	13
1862	March . . .	Gethin	47
1862	December 8 . .	Edmunds Main, Worsbro' Dale . .	59
1862	April 4 . . .	Snowhill Pit, Chapeltown . .	6

Year	Date	Name of Colliery	No. lost
1862	. . . .	Washington	28
1862	. . . .	Gwendraeth, South Wales . . .	27
1862	. . . .	Coppul	36
1863	October 17 . .	Swansea	39
1864	. . . .	Jane Pit, Houghton	—
1865	May 4 . . .	No. 2, Clay Cross Coal and Iron Co. .	8
1865	. . . .	South Wales	34
1866	. . . .	Bedwelty	21
1866	June . . .	Victoria Pit, Dukinfield . . .	40
1866	December 12, 13 .	Ardsley Oaks, Barnsley . . .	364
1866	. . . .	Highbrooks	30
1866	December 13 . .	Talk-o'-th'-Hill	91
1867	May 2 . . .	Cwmpennar, Aberdare	2
1867	November 8 . .	Ferndale Colliery, Wales . . .	178
1867	November 11 . .	Horner-hill Colliery, S. Stafford . .	12
1868	August 17 . .	Sand-lane, Hindley, Lancashire . .	3
1868	September 30 . .	Green Pit, Ruabon, Wales . . .	10
1868	November 26 . .	Hindley Green, Lancashire . . .	62
1868	December 21 . .	Norley Hall, Lancashire . . .	8
1868	December 30 . .	Queen Pit, Haydock, Lancashire . .	26
1869	January 7 . .	Rainford Colliery, Lancashire . .	7
1869	January 29 . .	Springwell, Durham	3
1869	February 9 . .	Fforchaman Colliery, Aberdare . .	3
1869	February 10 . .	Woodstone, Staffordshire . . .	4
1869	April 1 . . .	Highbrooks, Lancashire . . .	37
1869	May 25 . . .	Cwmnantddu, Monmouthshire . .	7
1869	June 10 . . .	Ferndale, Wales	53
1869	July 21 . . .	Queen Pit, Haydock, Lancashire . .	59
1869	October 22 . .	Newbury, Frome, Somersetshire . .	9
1869	November 11 . .	Hendreforgan, Swansea Valley . .	6
1869	November 15 . .	No. 5 Pit, Moss Coal Co., Wigan . .	27
1870	February 4 . .	Pendleton Colliery, Salford . . .	8
1870	February 14 . .	Morfa Colliery, Swansea . . .	29
1870	March 3 . .	Dukinfield Deep Pit	9
1870	April 9 . . .	Bathgate, Scotland	7
1870	July 24 . . .	Llansamlet, Wales	19
1870	August 10 . .	Brynn Hall	19
1870	August 26 . .	Wigan	27
1871	January 10 . .	Renishaw, Eckington	26
1871	February 27 . .	Carr House, Rotherham . . .	—
1871	September 6 . .	Wigan	69
1871	September 20 . .	Wigan	5
1871	November 15 . .	Wigan	6
1871	November 22 . .	Norwood, Killamarsh	9
1871	November 25 . .	Tankersley	2
1872	March 28 . .	Bolton, Lancashire	28
1872	October 7 . .	Morley, Dewsbury	—
1872	November 14 . .	Pelsall, Staffordshire . . .	22
1872	December 2 . .	Featherstone	2
1872	December 11 . .	Norley, Wigan	4
1872	December 21 . .	Silverdale, Staffordshire . . .	8
1873	October 1 . .	Silkstone Main, Barnsley . . .	[illegible]
1873	November 21 . .	Wigan	7
1874	March 2 . .	Blantyre, Scotland	2
1874	April 14 . .	Dukinfield	51
1874	July 18 . .	Wigan	19
1874	August 24 . .	Hanley	4
1874	November 20 . .	Rawmarsh	25
1874	December 24 . .	Staffordshire	17
1875	January 5 . .	Aldwarke, Rotherham	5
1875	January 6 . .	Duffryn, Dudley	2
1875	February 3 . .	Longton	2
1875	April 30 . .	Talk-o'-th'-Hill	43

Year	Date	Name of Colliery	No. lost
1875	May 17	Kilsyth, Scotland	2
1875	June 2	Little Lever, Bolton	—
1875	June 30	Bowling	3
1875	July 1	Dewsbury	4
1875	September 11	Donnington Wood	11
1875	October 7	Bedminster	4
1875	December 4	Tredegar, Monmouthshire	20
1875	December 6	Swaithe Main, Worsbro', Barnsley	140
1875	December 6	Pentrych, Wales	12
1875	December 9	Methley	6

Barnsley Chronicle, December 11, 1875.

COLOPHONY. The resinous substance which remains when turpentine or pine resin is heated till the volatile oil and water are evaporated. *Colophony album* is pale yellow and transparent. *C. commune* is brownish yellow and translucent. It may be obtained nearly colourless by distillation with steam. MALY considers from results obtained by him that the principal constituent of colophony is a resin-acid, having the composition $C^{44}H^{64}O^{5}$.—WATTS's *Dictionary of Chemistry*.

COLOURED FIRES. See PYROTECHNY.

COLUMBITE. This mineral has been found recently at the mica mines in Mitchel county, and in Yancey county near Burnsville, in the State of North Carolina.

An examination of the columbic acid minerals from new localities has been made by Mr. J. LAWRENCE SMITH, Louisville, Ky. He gives an analysis of columbite as follows:—

	Massive	Crystals
Columbic acid	80·82	80·06
Tungstic and stannic acid	1·02	1·21
Protoxide of iron	8·73	14·14
Protoxide of manganese	8·60	5·21
Oxide of copper	trace	—
	99·17	100·62

A columbite from Colorado associated with gigantic crystals of Amazon stone gave—

Columbic acid	79·61
Iron protoxide	14·14
Protoxide of manganese	4·61
Loss by heat	·50
	98·86

SAMARSKITE, EUXENITE, HATCHETTOLITE (a new columbate), ROGERSITE, and FERGUSONITE were all examined by the same chemist, and he is continuing the enquiry.—*Examination of American Minerals*, by J. LAWRENCE SMITH.

COLUMBIUM. (Vol. i. p. 903).—**TANTALUM.** (Vol. iii. p. 969). *Compounds formed with nitrogen and with carbon.* JOLY has made experiments with the compounds of these metals, formed by reducing at high temperatures their oxides in carbon crucibles. Heated to the temperature of the fusion of nickel for six or seven hours, long violet grey brilliant needles were obtained, which proved to be a mixture of carburet and nitride of columbium. One product, of a beautiful bronze-yellow colour, obtained at the temperature of melted steel, contained only 0·7 per cent. of nitrogen.

COMPOSING MACHINE, TYPE. See PRINTING.

CONCH, THE LARGE. *Triton variegatus* (?). This kind of fish is of two sorts, distinguished by the thickness or thinness of its shell. It is found largely in the Bahamas. That conch with the thinnest shell is generally the largest, and the other is the most ponderous. The outside is of a brownish white, studded at uncertain distances with blunt knobbed protuberances.

The inside is finely polished, and its colour near the extremity is of a pale red, further in of a deep maiden's blush.

The head of the fish is guarded with a black horny hook; this being extended out of the shell and fixed in the sand, by a strong muscular motion drags the fish with its cumbrous weight of shell after it. It is thought that the conch feeds upon lesser shell-fish, but outside the shell a fine whitish moss grows, upon which the fish often feeds, so that if it does not rely upon other sources for sustenance, it always carries, at all events, some part of its food with it. The broad-lipped conch has, as its name implies, a very wide mouth, with its lips much expanded. The first circumvolution of this takes up the greater part of the shell. The large brown conch is four inches long and about half as broad over the middle. The colour of this is of a shining brown, and the slip or mouth on each side is dentated.

CONCH, SMALL. (*Concha veneris alba*). These are often not a quarter of an inch long. They are not unfrequently called rice shells, and they very much resemble the grains of rice at a distance. Many exquisite examples of shell work are made of these shells.

In 1872 the value of the conch shells exported was only 170*l.* In 1857 this export is said to have been of the value of 6,351*l.*; for 1876 there is no return.

CONIFERIN. The glucoside contained in the cambium of coniferous woods. It is used for the production of the artificial vanilin. See VANILLA.

COPAL GUM. (Vol. i. p. 905.) In addition to the information given in the article in the first volume respecting the common gum, the African gum-resin is especially noticed. The Zanzibar copal is stated to be the product of *Trachylobium Hornemannianum*, and the Madagascar variety of some variety of the *Hymenæa*. (See *Treasury of Botany*, Part i.)

Copal trees are found in large numbers on the East Coast of Africa, and cover extensive tracts of country to the eastward of the Wasiungi range of mountains, from the Marni Hills to the southern extreme of the range near Kilwee, from latitude about 6° S. to 9° S., longitude 39° E. to 39° 16′. This district is not the only one, but it appears to be the principal field of labour known at present. The gum copal proper of this district is found at a depth of from three to five feet below the surface. It has been ejected from the trees at some indefinite and unknown distance of time. These trees have probably long ago decayed, but from existing ones gum still issues, though of an inferior quality.

At the foot of these mountains the copal trader, with his gang of slaves rudely armed, is to be found working at the diggings, filling baskets not only with genuine gum-resin, but with much that is added to deceive—such as clogged sand, new gum, and a large amount of the burnt and charred copal which has been at some time or other destroyed by surface fires passing over the sand. When all their baskets are full, the gangs may be seen making their way across the country, through many a mangrove swamp, to the various towns on the sea-coast, where live the Indian dealers who buy up the rough collection. When a sufficient quantity is obtained, the dealers forward it in boats to Zanzibar, for sale to the European merchants.

The process of cleaning the copal at Zanzibar for the Indian and English markets is as follows:—It is first placed in large tubs containing strong solutions of potash and lime, where it remains for several hours, until cleared of sand and dirt. It is then placed in baskets, ready for being picked. Gangs of from two to three hundred negroes, varying in age from 8 years to 40, may be seen in the copal stores of the merchants of Zanzibar, sitting in rows on the floor, with four or five small baskets round each negro. From one of the baskets they pick the various sorts of copal, placing them in separate ones, and rejecting what is not gum copal. When each has completed his task he takes the filled basket to a more experienced hand, who repicks it, and thus it is separated into its various sorts.

COPPER ALLOYS, *Comportment of, under the action of the blowpipe.*

Copper and tin unite under the influence of the reducing flame with a grey and partially malleable bead, the surface of which in the oxidising flame becomes more or less thickly incrusted with cauliflower-like excrescences of oxide.

Copper and zinc do not unite *per se* into a globule; the zinc burns into oxide. Under carbonate of soda they form brass.

Copper and lead form a dark grey globule, which may be extended on the anvil.

Copper and thallium melt into a dark malleable globule.—CHAPMAN on *Blowpipe Reactions*, *Phil. Mag.*, December 1876.

COPPER, ASSAY OF. The constant loss of copper in the assay of the copper ores in Cornwall has been thought to be due to the salt employed.

Mr. JOSEPH ROBERTS, of Widnes, made a series of very exact assays. He says: 'It will be seen by the table here given that in no case does the quantity of copper found in the regulus along with what is contained in the slags correspond to the quantity found in the ore, while at the same time it is more than what is given in the finished

"dry" assay. This, I think, is sufficient proof that some portion of the copper is lost without the use of any salt whatever, and must, I think, be put down to the volatile products formed in the fusion for regulus. I am also inclined to think that some of the copper is lost during the calcining, by being carried off mechanically by the sulphur.

No. of Sample	Quality	Ore, Dry Assay	Ore, Wet Assay	Difference	Regulus, Wet Assay
1	Purple ore	49·875	50·750	0·875	50·300
2	Yellow ore (sulphide)	30·125	31·000	0·875	30·560
3	Do.	17·825	18·500	0·675	18·340
4	Do.	16·214	17·000	0·786	16·855
5	Do.	9·275	9·750	0·475	9·425
6	Do.	11·500	12·000	0·500	11·746
7	Do.	11·275	11·725	0·450	11·500
8	Do.	7·875	8·452	0·577	8·000
9	Do.	8·180	9·000	0·820	8·410
10	*Carbonate*	27·250	27·750	0·500	27·490
11	Do.	19·510	20·250	0·740	19·833
12	Do.	27·500	28·750	1·250	27·725

The Chemical News, xxxii., February 1876.

COPPER ORES AND COPPER.

Production of Copper in the United Kingdom for 1874 and 1875.

1874.

Counties, &c.	No. of Mines	Ore	Value of Ore			Copper			Value of Copper (*Compounded*)		
		Tons	£	s.	d.	Tons	cwt.	qrs.	£	s.	d.
ENGLAND.											
Cornwall . .	76	40,455	201,367	18	8	2,770	14	0	249,263	0	0
Devonshire . .	14	12,826	52,746	0	0	916	2	0	282,440	10	0
Cumberland .	3	813	3,663	7	10	56	18	1	5,050	0	0
Lancashire . .	2	945	4,128	5	10	75	0	0	6,750	0	0
Cheshire . .	1	8,184	6,475	0	0	89	9	2	7,900	0	0
Yorkshire . .	1	128½	2,608	11	0	35	0	0	3,150	0	0
Staffordshire .	1	½	2	0	4	0	0	2	2	16	0
WALES.											
Cardiganshire .	2	93	338	5	6	5	16	2	522	15	0
Carnarvonshire .	2	138	632	0	0	9	12	2	865	0	0
Anglesea . .	3	4,025	5,250	0	0	135	1	0	12,150	0	0
Merionethshire .	1	5	45	0	0	0	15	0	67	0	0
Montgomeryshire.	2	84	580	0	0	6	0	0	570	0	0
Isle of Man . .	1	61	299	6	4	5	8	0	470	0	0
IRELAND.											
Sold at Swansea Ticketings . .	5	8,778	50,218	10	0	716	4	0	54,440	0	0
Wicklow . .	3	907	4,120	13	0	85	10	0	7,650	0	0
Regulus, *Precipitate, &c., sold at Ticketings* . .	—	100	950	0	0	74	0	2	6,600	0	0
Total of the United Kingdom, 1874 . . .	110	75,521	336,411	18	6	4,981	11	5	447,501	3	0

1875.

Counties, &c.	No. of Mines	Ore	Value of Ore			Copper			Value of Copper		
		Tons	£	s.	d.	Tons	cwt.	qrs.	£	s.	d.
ENGLAND.											
Cornwall . .	67	39,393	204,228	7	9	2,697	19	2	242,815	10	0
Devonshire . .	17	14,097	86,308	7	1	1,006	17	2	90,616	10	0
Cumberland	1	142	710	0	0	9	18	3	804	7	6
Lancashire . .	1	1,373	5,290	3	1	109	17	0	9,886	10	0
Cheshire . .	1	8,330	6,663	0	0	85	9	3	7,693	17	6
WALES.											
Cardiganshire .	1	79	395	10	10	4	18	2	447	15	0
Carnarvonshire .	3	127	635	0	0	8	16	3	727	7	6
Anglesea . .	3	4,612	9,224	0	0	126	9	0	11,380	10	0
Merionethshire .	1	16	80	0	0	1	2	0	99	0	0
Montgomeryshire	1	55	275	0	0	3	18	2	353	5	0
IRELAND . .	4	3,125	15,625	0	0	255	0	2	2,950	0	0
Regulus, Precipitate, &c., from Cornwall and Devonshire, sold at Ticketings .		173	879	3	0	12	8	3	1,119	7	6
Total of the United Kingdom	100	71,528	333,414	11	9	4,322	16	2	388,934	0	0

Summary of Produce from 1870 to 1875.

Year	No. of Mines	Copper Ore	Value	Copper	Value
CORNWALL.					
		Tons	£	Tons	£
1870	77	56,526	242,227	4,147	331,327
1871	79	46,766	205,025	3,340	258,850
1872	73	41,756	226,654	2,948	306,767
1873	68	40,255	188,236	2,973	235,110
1874	78	40,455	201,367	2,770	249,263
1875	67	39,393	204,228	2,698	242,815
DEVONSHIRE.					
1870	15	24,752	84,096	1,458	105,970
1871	14	24,352	79,400	1,342	104,005
1872	12	23,630	88,669	1,186	123,010
1873	12	14,810	46,200	809	77,583
1874	14	12,826	52,746	916	82,440
1875	17	14,097	86,308	1,007	90,616
UNITED KINGDOM.					
1870	124	106,698	437,831	7,175	551,309
1871	122	97,129	387,118	6,280	475,143
1872	117	91,893	443,738	5,703	583,232
1873	122	80,188	342,708	5,240	502,823
1874	119	78,521	336,415	4,981	447,591
1875	100	71,528	333,414	4,323	388,934

The Average Prices, Produce, and Standard of the Cornish Copper Ores sold from 1870 to 1875.

Year	Average price			Average produce	Average standard		
	£	s.	d.		£	s.	d.
1870	4	3	0	7	98	12	0
1871	3	16	6	$6\frac{5}{16}$	99	11	0
1872	4	13	6	$6\frac{1}{2}$	114	17	0
1873	4	8	0	$6\frac{1}{4}$	110	5	0
1874	4	5	0	$7\frac{1}{8}$	97	10	0
1875	5	0	0	7	110	0	0

Imports of Copper, 1875.

Principal countries from which imported	Ore	Regulus	Old, for remanufacture	Unwrought and part wrought	Copper manufactures
	Tons	Tons	Tons	Tons	£
Sweden	432	—	74	51	377
Norway	825	—	32	110	—
Germany	160	—	321	49	1,462
Holland	46	11	127	—	3,290
Belgium	—	330	90	16	1,961
France	1,888	124	100	634	50,181
Portugal, Azores, and Madeira	1,803	642	25	—	118
Spain	1,069	4,609	47	50	—
Italy	8,492	200	265	4	98
Greece	21	—	—	—	—
Turkey	38	—	4	1	—
Algeria	1,778	—	—	—	—
Cape of Good Hope	12,450	34	40	43	106
British India (exclusive of Ceylon)	17	—	3	44	—
West Australia	153	—	—	9	—
South Australia	4	—	22	5,025	—
Victoria	7	—	13	2,556	—
New South Wales	127	38	—	3,784	—
British North America	8,737	332	18	—	—
United States of America:					
On the Atlantic	103	646	—	56	2,096
On the Pacific	541	303	—	—	—
Spanish West Indies	335	73	9	10	—
Mexico	1,578	—	1	15	—
Bolivia	2,702	1,186	—	—	—
Chili	10,314	24,181	93	25,119	—

Summary of Imports of Copper, 1875.

Description of Copper	Quantities, Tons
Copper ore	53,663
" regulus	32,906
Old copper for remanufacture	1,497
Unwrought and part wrought	39,723
Copper manufactures	Value £72,670.

The Total Quantities of British and Foreign Copper Ores, Regulus, &c., smelted, and Copper produced in ENGLAND *and* WALES *in* 1875.

	Tons	Copper produced
Total copper ores of the United Kingdom	71,528	4,323
" foreign and colonial ores, &c., sold at Swansea Ticketings	16,294	3,743
" " ores and private purchases	70,212	16,140
" pyrites producing copper (see PYRITES[1])	480,000	9,000
	638,034	33,806

British Copper exported in the Year 1875.

Principal countries to which exported	Unwrought, in bricks, pigs, &c.	Mixed or yellow metal	Wrought copper of other sorts	Total of British copper (exclusive of ores)
	Tons	Tons	Tons	Tons
Russia: Northern Ports	420	126	1,257	1,803
" Southern Ports	14	—	359	373
Sweden	24	223	337	584
Norway	2	845	102	949
Denmark	32	85	53	170
Germany	2,654	995	480	4,129
Holland	2,022	549	360	2,931
Belgium	1,349	254	184	1,787
France	3,977	517	78	4,572
Portugal, Azores, and Madeira	4	133	194	331
Spain and the Canaries	81	84	94	259
Italy	281	1,635	544	2,460
Austrian Territories	20	230	30	280
Greece	—	34	174	208
Turkey: European	2	8	579	589
" Asiatic	—	3	434	437
Egypt	3	119	490	612
West Coast of Africa	—	35	29	64
British Possessions in South Africa	—	39	29	68
Mauritius	4	93	13	110
British India: Continental Territories	198	4,327	3,979	8,504
Straits Settlements	—	240	62	303
Java	—	131	169	300
Philippine Islands	—	116	21	137
China	—	177	77	254
Hong Kong	—	700	65	773
Japan	—	68	1	69
Australia: West Australia	—	12	1	13
" South "	—	42	20	62
" Victoria	—	180	123	303
" New South Wales	6	357	96	459
" Queensland	—	15	8	23
" Tasmania	—	34	2	36
" New Zealand	2	71	19	92
British North America	29	596	123	748
United States of America: On the Atlantic	1	256	14	271
British West India Islands and British Guiana	1	51	119	172
Foreign West Indies	—	65	204	269
United States of Colombia (New Granada)	7	12	22	41
Peru	—	56	42	98
Chili	—	102	64	166
Brazil	—	119	474	593

[1] These pyritic ores are imported, first calcined to obtain the sulphur which they contain, then the burnt ore is treated for the copper it contains, which is less than 2 per cent. and this yields a small quantity of silver and often gold.

Foreign Copper exported in the Year 1875.

Countries to which exported	Ore	Regulus	Old, for remanufacture	Unwrought and part wrought	Copper manufactures (value)
	Tons	Tons	Tons	Tons	£
Russia: Northern Ports . .	—	—	—	1,529	15,038
„ Southern Ports . .	—	—	—	21	6,622
Denmark	—	—	—	80	4,285
Germany	98	—	—	3,584	2,210
Holland	—	—	—	3,630	—
Belgium	—	—	—	2,205	463
France	208	—	9	2,208	200
Spain	—	—	—	205	—
Italy	—	—	—	114	145
Austrian Territories . . .	—	—	—	41	—
Turkey, European . . .	—	—	—	7	70
Wallachia and Moldavia . .	—	—	—	1	577
British India: Continental Territories	—	—	—	985	4,014
Other Parts	—	—	—	—	139

Summary of Exports of Copper, as per Parliamentary Returns.

Description of Copper	British	Foreign
	Tons	Tons
Copper ore	—	306
Unwrought, in bricks and pigs	11,144	14,682
Copper coin	71	—
Mixed or yellow metal	14,877	—
Wrought copper of other sorts	11,693	—
Old copper	30,785	9
Copper manufactures . . . . Value	—	£33,763

South Africa.—Copper exists in various parts of South Africa. In the Transvaal numerous native workings are known, where ores of this metal have been wrought for years. But the cost of carriage to the coast, and the little demand for such an article for supplying the neighbourhood or the interior, has prevented any attention being turned towards it. In the older rocks along the coast, from Natal to Port Elizabeth, veins containing copper ores are known to exist, and in one or two instances they have been wrought to some extent, but nowhere with remunerative results. Running northward along the coast to Namaqualand, the country is again cupreous, and in the tract of country immediately south of the Orange river considerable attention has been turned to copper mining. In one instance in particular extraordinarily good results have been obtained. This is the deposit belonging to the Cape Copper Mining Company, and from which a large profit has already been realised, and profits of about 80,000*l.* per annum are still (1877) being made in its workings. Numerous other smaller deposits have been and are still worked by the Cape Copper Company and other Companies.

The rock in which these ores occur is 'gneiss,' but the deposits of copper ore are of the most irregular nature, in no case partaking of the nature of mineral veins; but in many instances the ores of copper appear to enter into the composition of the 'gneiss' rock itself, as one of its integral mineral constituents. These ores require a very elaborate and hitherto too expensive a system of dressing, so as to concentrate them to a sufficient degree of richness to admit of their bearing the cost of land carriage to the coast, and of freight to Swansea, for smelting.

In other instances the ores occur in isolated patches in the rock, many of which are only of limited extent. The deposit of the 'Ookiep Mine' is of one of these, but for its magnitude and richness it has far exceeded any other discovery in the neighbourhood, and although it has now been followed from surface to a depth of 80 fathoms, it gives no signs of exhaustion.

In the native territory of Damaraland and Ovampoland, copper is known to exist,

and some quantities have been exported from the former country through Walfisch Bay. The country has, however, been very imperfectly investigated; nor have there been any fair facilities or hopeful inducements for the development of copper mining, on account of its unsettled state and the wars which are constantly recurring between the rival tribes of Hottentots, Damaras, and Wampos, but now that the country has been ceded to the government of Cape Colony, there is every probability that mining will receive the attention it deserves.

JAPAN.—The copper of Japan is of excellent quality, and takes a foremost place amongst the various kinds offered in commerce; it is remarkably free from antimony and arsenic, and yields from 2½ to 12 per cent. of copper; richer specimens are frequently found. The number of copper mines in Japan is large, but some of these are exceedingly small, some producing scarcely anything. In the year 1874 the total output of refined copper was 3,000 tons, but even this small quantity was the produce of more than 200 mines.

The finest copper mines in Japan are the Ani mines, situated in the district of Akita. In 1872 they furnished 395 tons of fine copper, 100 tons of lead, and 1,191 lb. of silver. These mines are still worked on the old Japanese system, the ore being got at by about 300 different adits, and the present proprietors show little disposition to adopt any improvements; but there is no doubt that if a more modern system of working were pursued the mines would be much more productive. The veins of the Ani mines which run east and west are rich in copper and poor in lead, while those which run north and south are rich in lead and poor in copper. There is a copper mine in the neighbourhood of Osaka, and it is about the best specimen of a Japanese mine worked by native methods. It is producing from 15 to 20 tons of crude metallic copper a month. This mine is so peculiarly situated in the mountainous district of Yamato, that it is doubtful whether the European method could be adopted here and carried out so successfully as the present native style. The vein has a comparatively slight dip, and is worked at several levels, the lower one serving as an adit. There is no systematic plan of working, but wherever the orey parts appear the ground is worked, and those parts only. The levels are driven and the ore removed by means of gunpowder, and the broken ore carried to the surface by men and women. The vein consists of calcspar, quartz, magnetic pyrites, iron pyrites, and copper pyrites, the pyritous parts varying in width from 18 inches to 3 feet or more, occasionally being split into two veins, and often ending abruptly.

The following analysis of a crude copper from Washia may be taken as fairly representing the average composition of good qualities of Japanese crude copper:—

Copper	98·940
Lead	trace
Sulphur	·947
Iron	·101
Silver	trace
Arsenic	trace
Antimony	absent
	99·988

MR. GOWLAND says that Japanese copper, when properly selected and refined, should be of high value for electro-telegraphic purposes, where freedom from arsenic and antimony is especially required, these metals when present reducing the electric conductivity to a serious extent.

Osaka is the chief depôt for Japanese copper. There seems no special reason why it should be so now, but it arose from the fact that Osaka was the first place where there was a good refinery. The principal foreign market at present is Calcutta. It is estimated that by the present native method of getting the copper, each ton costs 38*l.* 15*s.* 10*d.*; this does not include freight to seaport or other market.

The following is a list of provinces producing copper not already mentioned:—

Province.	Class of ore found.
Yechizen	Old and large mines, producing the best copper.
Setsu	Excellent copper, out of copper pyrites.
Sendal	Good copper, out of copper pyrites.
Ugo	Good copper, out of copper glance and copper pyrites; contains silver and gold.
Satsuma, Tamba, Bingo, and Kii	Out of grey copper ore and pyrites containing gold.

Province.	Class of ore found.
Tyo	Good copper, out of grey copper ore and copper pyrites.
Hinga and Awa	Good copper, out of grey copper ore and copper pyrites, containing gold.
Tosa, Bishui Mine, and Yeshiu	Good copper, out of copper pyrites; grey copper ore.
Twami, Yechigo, Omi	Old and large mines, containing gold and silver in considerable quantities.
Sado, Wakasa, Kai, and Kaga	Good copper, out of copper pyrites, containing gold.
Tasima	Good copper, contains silver.
Chikuzen, Twashiro, Hikoshiu, Tnaba, Hida, Tdzumo, Tsé, Mimasaka, Suwo, Masashi, Kotsuké, Noto, Shimotsuke, Aki, and Bungo	Out of fine copper pyrites, containing some gold.
Buzen, Higo	Out of copper pyrites.

MAGELLAN.—Copper is said to exist in quantity in the colony of Punta Arenas or Sandy Point, in the Straits of Magellan. Mr. RUMBOLD, the British Minister at Santiago de Chile, in his yearly report, draws attention to this.

NEW SOUTH WALES.—Native copper has been found in New South Wales in association with cuprite, malachite, and other oxidised copper ores, as at Carcoar, the Canobolas, Wellington, Mitchell's Creek, Bathurst, Pink's Creek, Bell River, Peel River, Manilla, Bingera, Cobar. It occurs in smaragdite on Molong Creek, at Peelwood with lead ores. The late Mr. STUTCHBURY reports that at Kelloshiels the well-water was found to be so impregnated with copper as to be unfit for domestic purposes.

Malachite.—Green carbonate of copper occurs massive, also mamillated and botryoidal with fibrous concentric structure, the various layers often possessing different shades of colour, and forming a most beautiful and valuable stone for ornamental and inlaying purposes. Crystals are occasionally met with, and sometimes of large size; those from the Cobar Mines are particularly beautiful. The silky lustre is often very remarkable, the capillary crystals sometimes being several inches long.

It is found in most of the surface workings of New South Wales copper mines, as in the Bathurst district with chlorite, vitreous, yellow, and other copper ores; at Cambalong earthy and fibrous malachite is associated with barytes or heavy spar, and with yellow and peacock ore; at Cobar, with steatite; Mitchell's Creek, Wellington, mixed with other surface ores, and often containing large quantities of gold and silver; Reedy Creek, Icely, Peelwood, Yass, Bingera, and other places.

Professor ARCHIBALD LIVERSIDGE, in a paper read before the Royal Society of New South Wales, gives the following list of varieties of copper ore found, and the localities in which it is found in that colony:—

	Localities.
Cuprite (copper suboxide) Chalcotrichite (plush copper)	Cobar, Clarence River, Bathurst, Mitchell's Creek, Wiseman's Creek, Carcoar, Icely, Burrowa, Molong, Manilla, Bungonia, Yass, Peelwood, Bingera.
Tenorite (black oxide)	Carcoar, Wellington, Icely, Peelwood, Burrowa.
Malchite (green carbonate of copper)	Bathurst, Cambalong, Cobar, Mitchell's Creek, Wellington, Icely, Reedy Creek, Peelwood, Bingera, Yass, and other places.
Chessylite Azurite (blue carbonate of copper)	Cobar, Woolgarloo, South Wiseman's Creek, Inverell, Bathurst, Ophir, Peelwood, Icely.
Atacamite (hydrous oxide of copper)	Cobar and Cowra Mines.
Chrysocolla (hydrous silicate of copper)	Coombing and Cobar.
Phosphocalcite (hydrous phosphate of copper)	Coombing Copper Mine.
Redruthite (copper glance)	Cobar, Manilla Waters, Wellington Caves, Wellbank, Carriangullong, Bathurst, Kroombit, Icely, Carcoar.
Bornite (purple ore)	Cobar, Bingera, Wellbank, Wellington.
Fahlerz (grey copper ore)	Copper Hill, near Molong.
Chalcopyrites (copper pyrites)	In nearly all the metalliferous districts of the colony.
Bell-metal ore	Cobar.
Domeykite (arsenical sulphide of copper)	Bathurst District.[1]
Antimonial copper ore	Eden, Twofold Bay.

The Produce of the Colony of New South Wales.

Year	Copper		Copper Ore		Total value
	Quantity	Value	Quantity	Value	
	Tons	£	Tons	£	£
1865	295	20,491	1,648	7,854	28,345
1866	304	23,390	947	4,745	28,135
1867	296	19,866	3,696	15,450	35,316
1868	315	21,420	3,161	12,780	34,200
1869	324	21,446	1,437	5,400	26,846
1870	297	20,060	84	336	20,396
1871	665	47,231	2½	44	47,275
1872	419	36,770	1,466	17,873	54,643
1873	160	14,500	5,877	142,126	156,626
1874	3,638	311,519	—	—	311,519
	6,828	558,193	21,897½	240,253	997,476

New Zealand.—Copper pyrites is found in Carrick, Otago, containing 13·5 per cent. of metallic copper. It is also found at Arrowtown, giving 11 per cent. of metallic copper, and at Moke Creek and at Waipori; the latter is stated to contain gold.

America.—*Copper Ore of Lake Superior.*—The copper of the Lake Superior mines is now tolerably familiar to all, but the mode of occurrence is not so well known.

The specimen from which the drawing, *fig.* 2311, is copied was from a vein running across the centre of Michipicoten Island. The metal occurs, as shown, in nuggets, varying considerably in size, scattered through calcspar veins.

The West Canada mines are the most important. The following account of them was prepared by the Geological Survey of Canada:—These mines are situated on the Bruce, Wellington, and Huron Copper Bay Locations, which adjoin one another, the Bruce being the most easterly. Work was begun on the last named in 1846, and has since been gradually extended westward, across the Wellington and on to the Huron Copper Bay, the whole length of the workings comprising nearly 4 miles. The veins are of white quartz, cutting, with a westerly bearing, a thick bed of dark green, finely crystalline diorite, associated with what is locally called the lower slate conglomerate of the Huronian series. On the Bruce location several nearly parallel veins of a similar character were opened, the main one having a thickness of about 4 ft., but on the other two locations operations have been confined almost entirely to two master veins, known as the fire lode and the new lode. These are about of equal size and vary from 4 to 20 ft. in width, averaging in the parts wrought 10 to 15 ft. Near the surface, especially on the Bruce location, a good deal of purple or horse-flesh ore was found: but, in working down, this was soon replaced by the yellow sulphide in all the veins. On the Bruce location a great number of shafts were sunk, but all the workings were between the surface and 30 fathoms, while on the other two locations they extend a little below 60 fathoms. On the course of the new lode on these locations, an almost barren floor has been met with nearly all along between the 40 and 60 fathom levels, but the vein maintains its strength, and it is believed that below this floor it will prove as rich as it is above it. The vein-matter brought to the surface appears to contain on an average about 5 per cent. of copper; but this is all crushed and very much concentrated for shipment to England. Reverberatory smelting furnaces were erected by the Montreal

2311

COMPANY in 1853, but afterwards abandoned. In 1869, 1870, and 1871 the present owners erected extensive and costly works for reducing the ore by LONGMAID'S or HENDERSON'S wet process, for which cheap salt could be obtained from Goderich, Kincardine, &c.; but, owing to the want of skilled overseers and workmen, the operation could not be carried on satisfactorily, and the company are again exporting all their ores.

The table below, compiled from authentic sources, shows the results of the working of these mines up to 1875—a period of 30 years. The total amount of the sales of the copper ore and copper to this date has been about $3,300,000, and this has afforded a good average profit.

Table showing the Amount of Copper Ores and Copper sent (principally to Great Britain) from the Bruce, Wellington, and Huron Copper Bay Locations from 1847 to 1875, both inclusive:—

Year	Location	Kind	Per cent. of copper	Tons of 21 cwt.
1847 to 1857 inclusive	Bruce	Yellow, variegated and vitreous sulphides	19·00	2,755
1858	Bruce and Wellington	Do. Do.	21·94	1,077
1859	Do. Do.	Do. Do.	21·35	1,684
1860	Do. and Huron Copper Bay	Do. Do.	20·50	2,051
1861	Bruce (tons) 472 Wellington 1,173 H. C. Bay 415	Yellow, with a little of the others	19·00 (average)	2,000
1862	Bruce (tons) 580 Wellington 1,277 H. C. Bay 1,069	Mostly copper pyrites	19·63 (average)	2,726
1863	All three combined	Nearly all do.	20·00	3,103
1864	Do.	Do.	18·48	2,940
1865	Very little from Bruce	Do.	21·21	1,834
1866	Do.	Do.	20·00	3,640
1867	Do.	Do.	20·00	2,743
1868	Wellington and H. C. Bay	Copper pyrites	20·00	2,504
1869	Do. Do.	Do.	19·50	2,180
1870	Do. Do.	Do.	18·75	2,162
1871	Do. Do.	Do.	19·00	1,721
1872	Do. Do.	Pyrites 1,166 Precipitate 15 Ingots 126	about 18·00 " 60·00 " 100·00	1,306
1873	Do. Do.	Pyrites 1,212 Slags 89 Precipitate 49 Copper 26	" 18·00 " 10·00 " 80·00 " 100·00	1,319
1874	Do. Do.	Pyrites	" 18·00	903
1875	Do. Do.	Do.	" 19·00	588
		Total Quantity		40,215
		" Value		$3,300,000

MEXICO.—*Copper Ore, Pitchy.*—This mineral is introduced in large quantities from Mexico into Liverpool, and was incorrectly entered as pitchblende. It occurs thoroughly intermixed with chrysocolla, is a dark brown colour, almost black; hardness 4·0.

Analysis by W. H. HUTCHINGS:—

	Per cent.
Silica soluble in Na^2Co^3	20·63
Silica insoluble in "	7·36
Oxide of copper	28·50
" lead	0·41
" iron	10·94
Alumina	0·15
Oxide of manganese	17·53
Oxygen	3·60
Oxide of cobalt	0·35
" zinc	1·54
Lime	0·92
Water	8·20
	100·31

Chemical News, September 29, 1876.

PRUSSIA.—*Copper Ore Produced in Prussia*, 1873 :—

Provinces	Weight of ore extracted	Value per ton
	Tons	Francs
Silesia	5,143	9.40
Saxony	229,680	33.60
Hanover	7,111	85.48
Westphalia	37,027	8.13
Hessen Nassau	4.275	26.10
Rhine Provinces	1,773	81.27
Total and mean product of 1872	{ 265,009 { 273,347	31.25 31.15
Increase	6,662	0.10

Zeitschrift für das Berg-, Hutten-, und Salinen-Wesen im Preussischen Staate, vol. xxii. 1874.

COPPER PHOSPHIDE. Phosphorus bronze is used extensively in several of the large German bronze-casting houses, on a larger scale, indeed, than in this country. H. SCHWARZ says they prepare the copper phosphide by putting sticks of phosphorus into crucibles containing the melted copper. To avoid the too ready combustion, the sticks of phosphorus are coated with a firm layer of copper by placing them in a solution of sulphate of copper. The quantity of phosphorus penetrating the bronze is very small —half a per cent. is said to be sufficient. Where much phosphorus is wasted, it is proposed to fill a clay tube closed at one end with sticks of phosphorus coated with copper, or with powdered red phosphorus, and placing the open end of the tube into the melted copper. If the tube is pressed to the bottom of the melted metal, the fumes can escape only by passing through the mass.

The phosphide of copper is also easily obtained by lining a crucible with bone ashes, silica, and coal, adding granulated copper, and covering it with a layer of the same mixture. At a strong fusion the silicic acid acts on the phosphorus, taking away the base. The phosphoric acid is reduced to phosphorus, and this is absorbed by the copper in the same degree as it is formed.—*Dingl. polyt. Jour.* ccxviii.

COPPER, PITCHY. See COPPER, *Mexico*.

COPPER PYRITES. Chalcopyrites is a very abundant ore in New South Wales. It usually occurs massive; occasionally crystals are met with, but they are generally but imperfectly developed. Blister ore is more of a bronze colour, and occurs in mammillated and botryoidal forms. The tarnished variety of copper pyrites, known as peacock ore from the splendid colours which it acquires, is very common.

It occurs in nearly all the metalliferous districts in the colony: at Cobar, Bingera, Elsmore, Clarence, Wiseman's Creek; Wellington and Bathurst Districts, with zinc blende, steatite, quartz, and asbestos; Wallabadah, Canoar, Cargo, Ophir, Peelwood, Tuena, Bungonia; at Currowang, on the Shoalhaven; Adelong, with gold; at Lob's Hole, on the Tumut; Kiandra.

COPROLITES. (Vol. i. p. 948.) The following analyses were by Mr. JOHN HUGHES, F.C.S., of the Chemical Manure Works, Deptford. A and B were samples of Cambridge coprolite, C was a sample of Charleston phosphate—a phosphatic deposit which has been used with advantage instead of Cambridge coprolite for the manufacture of superphosphate :—

	By the usual plan, without evaporation of the original acid solution			After evaporation and complete dryness of the original acid solution		
	A	B	C	A	B	C
Insoluble siliceous matter	8·10	8·70	10·05	9·20	8·50	11·5
Lime	42·70	42·68	42·08	42·68	42·50	42·00
Phosphoric acid	26·90	26·85	27·00	25·50	25·40	26·20
Equal to tribasic phosphate of lime	58·72	58·61	58·94	55·23	55·45	57·10
Silica left in magnesia phosphate precipitate	2·05	1·05	0·95	0·30	0·50	trace

Published in the *Chemical News*, No. 807.

Coprolites and phosphatic nodules were produced by the following firms and individuals in this country in the years 1875 and 1876:—

Coprolites and Phosphatic Nodules, &c.

Cambridgeshire and Bedfordshire:	Herbert Fordam, Royston
Noble and Co., Needham Market	W. Wallis, Duxford
Packard and Co. (*Grey Coprolites*)	F. J. Carter, Whaddon, Royston
W. Colchester and Sons	F. Smith, Mill House, „
Messrs. Fisons and Co.	G. C. Colchester, Therfield, „
Messrs. Chapman and Co.	Charles Roads, Meldreth, „
Messrs. Lenneet and Co.	H. Morgan, Whaddon, „
Messrs. Lawes and Co.	W. Weston, Hitchin

The total production of the above and other firms, as far as it has been possible to obtain information, was about 250,000 tons in each year, valued at 627,000*l.*

CORN DRIER. The following description and figures fully illustrate the steam corn drier introduced by Messrs. Davey and Paxman:—

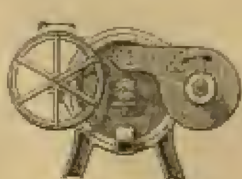
The grain comes into contact in this machine with pure hot air only, and steam-heated cylinders, therefore, however delicate its nature, it will receive no damage in colour or quality, an advantage which coffee growers and merchants have already shown that they appreciate. As a malt drier this machine has proved itself most efficacious, whilst the farmer, whose wheat has by any accident got damp, may save his grain from sprouting by the inexpensive operations of this drier.

2312

In the drawing, *fig.* 2312 represents a longitudinal section of the apparatus, *figs.* 2313 and 2314 the front and back respectively, while *fig.* 2315 is a section of the drying cylinder. The cylinder A A, which revolves on its horizontal axis, receives steam from the boiler by means of the inlet, 7, and a small indiarubber tube; the steam leaves the cylinder at its opposite end by the tube, H, which conducts the steam into a second cylinder, D, which is steam jacketed, and which surrounds the inner cylinder. The grain or other matter which has to be dried is fed into a hopper, I, falls between the

2313

2314



2315

feed rolls, which regulate the supply, and passes into the corn chamber, C C, which communicates directly with the free space between the two steam-heated cylinders. On the outer surface of the cylinder, A, are fixed perforated helicoidal agitators, fitted with brushes. By the rotation of this cylinder the corn is directed towards the farther

extremity of the apparatus, and falls at the same time by its own gravity against the second cylinder, D; being thus subjected to the radiated heat of these two cylinders, and meeting, in addition, a current of hot air moving in a direction opposite to that of the corn. An air chamber, E, surrounds the cylinder, D, cold air from the outside entering by a series of air holes, K' K' K', &c., 63 in total number, a draught being kept up by the fan, M, which is placed at the farther end of the apparatus, and worked by the driving pulley, F. The cold air drawn into the apparatus, at the openings, by the fan, is gradually heated by contact with the outer surface of the steam cylinder, D, and is then forced by the fan into the space, C, whence it passes into the tube, N, which is the outlet for the dried corn. The outlet pipe, O, serves as an outlet for the condensed steam, which is returned by a flexible tube to the water tank, the feed water being thus heated; the other for the vapours caused by the process of drying; a safety valve is also placed on the cylinder, D; L is the hot-air inlet, the orifice by which the hot air finds its way into the corn chamber, C.

In *fig.* 2313, A and D represent the outlets for steam; B is the toothed wheel, which revolves the cylinder D, and C the hopper.

In *fig.* 2314, A is the internal cylinder; B B are the perforated agitators; C the corn chamber, in which the drying takes place; D D is the second cylinder; E is the air chamber, and F is a support for the small axis.

The length of the cylinders is 12 ft., the inner cylinder is 12 in. in diameter, driven by cog gearing 14 to 104, the spindle making 34 turns a minute. The proportion of fuel required was found, by experiment, to be 1 lb. of coal to 2 bushels of corn, soaked over night with 14 lb. of water. This was dried at the rate of 30 bushels an hour, the pressure of steam in the cylinder being kept under 5 lb. to the square inch. The corn in this experiment was not completely desiccated till it had been passed twice through the drier, but all ordinary dampness would, it is evident, be removed at a single operation. This useful apparatus is constructed by DAVEY, PAXMAN, AND CO., of Colchester.

CORUNDUM. (Vol. i. p. 953). EMERY, vol. ii. p. 264. Mr. C. W. JENKS, of Boston, stated to the American Institute of Mining Engineers, that the chief sources of supply were certain districts in the Himalaya Mountains, in Hindostan; that, as far as is known, the corundum was never legitimately mined in those districts, but it was picked up in the river valley, where it was washed by the annual rains. The amount of corundum obtained in this way is small, not amounting to more than 20 tons per annum. Within a few years discoveries have been made of veins carrying pure corundum in the Western slopes of the Blue Ridge Mountains, in North Carolina. These veins traverse the dykes of chrysolite and serpentine, and are mainly composed of chlorite and chloritic minerals carrying with them masses of corundum. Experiments have been made with this corundum at the Springfield Armoury, and it is found, from its purity, to excel the Naxos emery. It is stated that this corundum can be put in the market, cleaned and graded for use, at the cost of 20 cents per pound.

CORALLINE. The name given to an artificial substance, somewhat resembling coral, which is made by combining camphor and gun cotton. See PARKESINE, vol. iii, p. 516.

COSTRA. The deposits overlying the *caliche* or natural deposit of nitrate of soda in Peru.

COTO BARK. Coto bark occurs in commerce in short pieces from 5 to 10 English inches in length, some flat, others slightly curved. It possesses a very powerful aroma, and the taste is aromatic. The bark is very brittle, and, owing to the quantity of resin it contains, difficult to reduce to fragments. According to Wittstein, coto bark contains an essential oil, a volatile alkaloid, and a soft and a hard resin. The crystalline constituent of the bark amounts to 1·5 per cent. of its weight. The cotoin obtained forms yellowish-white crystals, the formula obtained being $C^{22}H^{18}O^{6}$.

COTOIN. An alkaloid found in coto bark. See COTO BARK.

COTTON. The United States—the greatest cotton-producing country in the world—it might have been supposed, would have displayed in the greatest profusion and variety its native cotton at the Philadelphia Exhibition. There was some very admirable cotton shown, but nothing like the completeness of display which was desired; and especially do we miss a general and well-arranged illustration of the numerous local varieties of staple. The main points in the history of American cotton production for the last twenty years are pretty generally known; a few years immediately preceding 1860, a year of abounding prosperity among cotton planters, with constantly and rapidly increasing production, until an annual crop of something like 2,000,000,000 lb. had been attained. The outbreak of civil war produced a sudden falling off, leading, in 1863 and 1864, to an almost complete arrest of cultivation. The

immense disadvantages growing out of disorganisation of labour and the grievous injury inflicted upon the ditches and fences of previously well-tilled fields by four years of neglect, led to a very irregular production. The struggles and difficulties of a people gradually settling down to a new state of civil existence after the exhausting throes of deadly strife, naturally gave rise to the greatly diminished crops which existed for some years; but greater stability has begun to be attained, and the annual production of cotton has risen to almost its former imposing proportions. A much longer period is required for the education to habits of skilled, well-applied, and steady labour of the actual toilers in the field, still very far from being controlled by the higher motives of thrift, foresight, and economy.

The best general display of the cottons of the world at Philadelphia was made by Claghorn, Herring, and Co. This contained a large number of samples drawn from American and other sources, as well as many whole bales of some of the principal varieties. Some of the Sea Island long staple cotton was beautiful, a superb sample from Florida especially so, a State which shares with South Carolina and Georgia the credit of producing this finest and most valuable of cottons. Choice samples of Upland cotton were shown; one variety from Texas, where cotton culture is now rapidly extending, and one from the Red River, in Upper Louisiana, was of well-marked character. The distinction between Sea Island and Upland cotton is well known, not only in the greater length and fineness of the former fibre, but also in its seed being black and smooth, the fibre coming off cleanly from it, in ginning, while Upland cotton seed is greenish and covered with short down, the remains of the adherent fibre which has been broken off. The general belief of cotton planters, however, is that both are varieties—a superior and inferior—of the same plant, and that although Upland cotton planters near the sea coast cannot be made to acquire long staple, Sea Island seed, if sown at a distance from the coast, gives rise to plants which in one or two seasons at furthest degenerate completely into short staple, fibrous-seeded cotton. Some experiments made a few years ago appeared to show that Sea Island cotton in the interior, at a long distance—fifty or sixty miles—from all other cotton, would preserve its character through several generations of seed, and suggest the possibility that the reversion usually observed may be more the result of hybridisation than of change of climate and soil. As it is, the production of the choice Sea Island cotton is confined to an extremely small area.

Amongst the most interesting cottons from other countries were some from India, illustrating the extent of improvement attained by improved methods of cultivation and cleaning; very excellent specimens from Australia—Queensland—whose value is admitted to be on a par with that of America; and some samples from the Fiji Islands and from Algeria, the last-named being of long, delicate, silky fibre, adapted for spinning the highest numbers of spool thread.

Recently, at the Manchester Scientific and Mechanical Society, Mr. Evan Leigh lectured on Cotton Mills. Many points of considerable interest were noticed; especially he alluded to ring spinning and belt driving, both of which were eminently calculated to save power, and consequent waste of fuel. Referring to ring spinning, he said that it had been introduced into England as an American invention more than forty years ago, but for some reason it was not generally adopted by the English spinners. Perhaps that was owing to the then recent failure of the Danforth throstle, another American invention of great promise, that had been adopted by several spinners. Although the principle of the two frames was totally different, the English spinner was not to be caught again, so he fought shy of the ring frame, and it was believed that for more than thirty years not one frame on that principle was used in Great Britain. The solid advantages of this method of spinning were, however, duly appreciated in America, and the system was cultivated until the difficulties and exact mechanical requirements attending its construction were thoroughly mastered, and the result was the production of a frame that took only half the power of an ordinary flyer-throstle, besides being capable of working practically at a much higher speed. At the Laconia Mill, Biddeford, Maine, Mr. Leigh saw, last year, a girl minding, apparently with ease, 1,344 spindles of these frames, with the front rollers running seventy revolutions per minute, spinning No. 26 yarn, and found it quite common for such piecers to run 1,100 or 1,200 spindles with so little hurry, that they had plenty of time to avail themselves of a seat which was provided for each spinner, on which she sat and leisurely watched the frames spin. He (Mr. Leigh) did not think that this arose from superior ability in the American, but simply that in foreign countries spinners are less jealous of one another, and band themselves together to discuss and test scientifically all alleged improvements.

Going on to speak of the comparative advantages of belts and gearing, Mr. Leigh said that the proper application of driving belts to the machinery was a most important question. To be rightly applied, a main driving belt should move through

4,000 or 5,000 feet of space per minute, and be sufficiently wide to drive all the machinery and shafting quite easily when running in a slack state. After a new belt had been once tightened up, it should work many years without wanting any further tightening, and would do so if made of good material and properly applied, saving in the meantime a large amount of power and all the grease and labour of putting it on, to say nothing of the noise heavy gearing makes. He then adduced some practical instances of the extent to which belt power might be used in connection with machinery, giving examples from the various mills he had visited in America, showing the durability and ease with which large belts did their work. The lesson taught by the big belt was imperative, viz. that there should be very light shafting run at a very high speed, with larger drums and pulleys; then very little would be heard of strap-piecing, or wear and tear of belts, working with less power and steadier production all the while. The simplest and best, and also the cheapest and most durable, method of driving by belt was to convey the power from the main driving shaft direct to each room by a separate strap, and if more than one shaft was wanted in any room to drive it from the other direct by a separate strap, apportioning the width of each strap to the power it was required to drive, and whenever a belt was necessarily short, allowing a little extra width.

On this subject a series of papers ('Belting Facts and Figures,' by J. H. COOPER) which have appeared in the *Journal of the Franklin Institute*, should be consulted. An article by F. H. STEBBINS, in the same journal (vol. ci. pp. 101, 169), 'Cotton Manufacture and the Ring Frame,' merits attention.

COTTON PLANT. (Bamia.)—The following has a peculiar interest. It is an extract from the Alexandria correspondent's letter to the *Times*:—

'Everyone knows the story of M. JUMEL, who, 50 years ago, walking in the garden of a Turk at Cairo, noticed how well a certain cotton tree flourished, and how he took away the seeds therefrom, and planted and replanted them until he founded the present cotton culture of Egypt. Well, it appears a Copt has now made a "new departure" of a similar kind. The results already obtained from the new plant are most extraordinary. It compares with the old as follows:—An ardeb (270 lb.) of ordinary cotton seed sows on an average eight feddans (acres), and produces four cantars (100 lb.) of cotton in seed—that is to say, the cotton with the seed inside it as it comes out of the cotton pod. Taking this yield as the average, every ardeb planted produces 32 cantars of ginned cotton and about 24 ardebs of seed. An ardeb of seed of the new species sows, like the other, eight feddans; but its yield is more than treble, and has even been stated at fivefold. But my most trustworthy informant only gives ten cantars per feddan, which I may add is the amount taken by one of the leading firms as the basis of their calculations as to the effect of the new plant. They add that it is difficult to say exactly what would be the ordinary yield, as all returns hitherto are the result of exceptional culture on a small scale. On this calculation of ten cantars, each ardeb of seed would produce 80 cantars of cotton in seed—that is to say, over double the amount produced by ordinary seed. At present prices each ardeb would return about 240*l.* in seed and cotton together, instead of 96*l.*, as it does now. The new cotton, I am assured on the best authority, is of good appearance, commercially speaking, and quite equal in quality to ordinary Egyptian cotton. The plant grows in a different manner to the ordinary cotton plant. It grows to about the height of ten feet, has a straight vertical stem, without branches, with very few leaves, and is thickly studded with pods. Seventy are said to have been gathered from the first plant discovered. The ordinary cotton is found on a shrub, some four to five feet high, with spreading branches. Nearly a yard must be left for air, light, and growing room between each shrub, whereas the new plant, from the absence of branches, requires only half the space. This fact is of material importance with a view to its capabilities of production in a given space. It is called here *Bamia cotton*, from the resemblance of the plant to a vegetable of that name, and the Arabs maintain that it is the result of a cross between the two shrubs. But others say it has been brought from the Soudan, or Equatorial Africa. Nothing, however, is positively known. The history of its discovery is curious. A Copt living in the upper part of the delta, at a place called Berket el Sab ('Well of the Lion,' a station on the Cairo Railway), in the province of Menouf, noticed in the autumn of 1873 a plant in a cotton field wholly different to the rest. He collected the pods, separated the seed, and planted it in secret in an isolated plot of ground. For three years he has carried on the cultivation, and now there are said to be from three to four hundred ardebs in the country, and the seed is sold in public market. I am told that as high as 25*l.* and even 30*l.* per ardeb is paid, instead of 1*l.* All has been bought up, and the supply is exhausted. Supposing that all these wonderful facts are true—and I have them from good authority—a small revolution in our prospects

is at hand. If, as is stated, there are 400 ardebs of seed ready for sowing this March, and it multiplies itself by 60, as above stated, we shall have for the following crop about 24,000 ardebs, and for March 1879 there will be enough to sow the cotton country ten times over, as there are only 700,000 peddans in the whole of Egypt which are fit for cotton culture. Going one step further, and supposing that the new plant supplants the old, we should have a crop of 7,000,000 cantars of cotton, and 5,000,000 ardebs of seed, while the largest crop ever known hitherto was produced last year, and only reached three millions of cotton and two and a quarter of seed. To put the comparison in the money form, we should have 21,000,000*l.* instead of 9,000,000*l.*'

Sir JOSEPH HOOKER, the Director of the Botanical Gardens at Kew, obligingly informs us that seeds of the Bamia cotton were sent to the Gardens by the Vice-Consul at Alexandria; and that they have seedling plants in the gardens, but they are not sufficiently advanced to determine the kind.

The following remarks on the cotton of Central Asia are from a Report made by M. BRODOFSKY to the Russian Government, which was published in the *Golos* of September 3, 1876:—

'Steps are being taken in Russia for the improvement of the cotton received from Central Asia. Of the 50,000 cwt. yearly worked up (in 1871) by Russian manufacturers, only 10,000 cwt. are received from Central Asia and Persia, the rest coming through Liverpool from America (23,300 cwt.), and from India (16,700 cwt.) Central Asia produces now more than 50,000 cwt., and this production could easily be doubled in a short time; but the Asiatic cotton is little used, as it is imperfectly cleaned, and has short fibres. Cleaned in Russia, there is a loss of 25 per cent. of weight, and (taking into account the high cost of the transport) of about 1½ rouble on the price of a pood (36 lb.) The imperfect cleaning of the cotton is due, of course, to the primitiveness of the methods used in Asia. As to the shortness of the fibres, M. BRODOFSKY, who was sent to America with the special purpose of studying the subject, supposes that it is not due exclusively, as asserted until now, to climatic conditions, but mainly to the circumstance that the cotton tree cultivated in Asia (*Gossypium herbaceum*, *G. indicum*) is a botanical species different from those cultivated in America (*G. Barbadense*, which gives the best Uplands kinds of cotton, as Mobile, New Orleans, &c., and *G. arboreum*, which gives the Sea Island kind). As to the last species, which produces the most highly prized cotton, experiments of its culture in Turkistan have already proved unsuccessful, the thread received being long and silky, but too feeble. It appears, however, highly probable, from the comparison of the climates of the central parts of Texas and of Turkistan, that the *G. Barbadense* can be profitably cultivated in Central Asia if certain measures are taken to improve the culture. The Society of Friends of Natural Science in Moscow had, therefore, elaborated a plan of an experimental farm for the culture, united with a station for the cleaning of the Bokhara cotton by American methods, and this plan was much patronised by General KAUFMANN. But work having been postponed owing to a want of funds, a private society has been founded, with a capital of 300,000 roubles, for the encouragement of the cotton trade in Turkistan on a large scale. The society has already received a lot of land of 103,200 acres, and has purchased 6,880 acres of artificially watered land for its farm. The cleaning engines, which have already proved during preliminary essays to be the most useful for the Asiatic cotton, will be received from America during this autumn, together with seeds of the *G. Barbadense*.'

Imports of Cotton.

	1873		1874	
	cwt.	£	cwt.	£
From United States .	7,481,041	31,725,672	7,894,161	29,611,282
" Brazil . .	651,045	2,866,631	709,998	2,761,820
" Turkey .	52,154	200,944	—	—
" Egypt .	1,528,630	8,594,792	1,528,213	7,219,966
" British India .	3,259,065	9,841,303	3,676,270	10,346,633
" other Countries .	396,537	1,657,778	253,433	926,508
Totals .	13,693,472	54,887,320	14,062,075	50,936,609

	1875		1876	
	cwt.	£	cwt.	£
From United States .	7,556,780	27,184,206	8,339,735	25,297,153
" Brazil . .	640,152	2,338,086	476,517	1,498,122
" Egypt . .	1,454,029	6,622,310	1,767,261	6,836,934
" British India .	3,446,121	9,255,392	2,470,102	5,927,356
" other Countries .	263,604	920,367	243,124	786,981
Totals . .	13,360,686	46,320,361	13,346,739	40,346,504

Value of Cotton Manufactures Imported.

1873	1874	1875	1876
£	£	£	£
1,553,772	1,482,513	1,280,674	1,810,859

Exports of Cotton.

Cotton Yarn and Twist.

	lb.	Value £
1874 . . .	220,682,919	14,517,125
1875 . . .	215,609,550	13,172,860
1876 . . .	232,150,400	12,782,664

Cotton Manufactures.

	Yards	Value £
1874 . . .	3,606,639,044	55,022,645
1875 . . .	3,562,462,160	53,626,926
1876 . . .	3,668,582,100	50,374,875

Total of these and other Cotton Manufactures.

		Value £
1874 . . .	—	59,730,200
1875 . . .	—	58,598,853
1876 . . .	—	54,850,966

The following estimate of financial resources in the cotton-spinning and manufacturing trade in Lancashire (including Dukinfield, Glossop, Hyde, Marple, Mottram, New Mills, and Stockport, in Cheshire) has been compiled by Mr. RICHARD SEYD, in April 1877:—

'Lancashire is the centre of the cotton-spinning and manufacturing trade not only of the United Kingdom, but of the world, by far the greatest part of the raw cotton imported into this country being spun and manufactured there, and the term "Manchester goods" is a "household word." The trade, although perhaps at present not quite as profitable as formerly, is still in a sufficiently flourishing condition, and the riches accumulated are in some cases fabulous.

'The following are the statistics of raw cotton imported and exported from 1870 to 1874, together with the value of imports:—

Years	Total Import	Total Export	Value of Total Imports
	lb.	lb.	£
1870	1,339,367,120	238,170,840	53,477,755
1871	1,778,139,776	362,075,610	56,907,070
1872	1,408,837,472	273,005,040	53,380,670
1873	1,527,6[illegible]6,224	220,000,256	54,704,847
1874	1,566,864,432	958,967,632	50,696,406

Years	Excess of Imports	Value of Excess of Imports
	lb.	£
1870	1,101,191,250	43,067,058
1871	1,416,064,160	44,622,370
1872	1,185,932,432	42,030,544
1873	1,307,596,065	46,826,403
1874	1,307,806,800	42,317,499

'In the spinning and manufacturing of this enormous amount of raw material there are about 1,900 firms engaged in the district above alluded to, including about 270 joint-stock companies under the Limited Liability Act. The nominal capital of these companies (many of which do not issue any report) may be estimated at about 15,000,000*l.*, of which it may fairly be taken that one-half (say 7,500,000*l.*) is paid up. The capital of private firms and individuals (numbering say about 1,600) can be placed at 50,000,000*l.*, based on such figures as are quoted below, giving an average of about 30,000*l.*, for each firm.

'The term "capital" must be taken here as representing not only the so-called working capital, but also those amounts sunk in plant, &c., as well as money invested apart from trade in real property, which, although not actively employed in commercial operations, is yet responsible for the liabilities of the individuals or firms, and may be regarded as "reserve fund." Besides the limited liability companies, with their paid-up capital of 7,500,000*l.*, there are six firms each estimated to possess resources exceeding 1,000,000*l.*; 12 ditto, 500,000*l.*; 26 ditto, 200,000*l.*; 60 ditto, 100,000*l.*; 72 ditto, 75,000*l.*; 101 ditto, 50,000*l.*; 106 ditto, 30,000*l.*; 155 ditto, 20,000*l.*; 258 ditto, 10,000*l.*; 280 ditto, 5,000*l.*; 187 ditto, 2,000*l.*; 200 ditto, 1,000*l.* The rest have little or no means.

'There can, of course, be no doubt that a considerable proportion of this capital consists of landed and house property, mills, machinery, &c., some of which may be quite unrealisable in times of depression or stagnation; but due regard has been given to these circumstances, and the estimates have been submitted to and approved by gentlemen who are thoroughly well acquainted with the Lancashire spinning trade.

'Although the spinning and manufacture of cotton forms the staple industry of Lancashire, there are other trades of considerable magnitude carried on, such as woollen and silk manufacturing, calico printing, bleaching, and dyeing, and the manufacture of iron, chemicals, glass, paper, hats, and indiarubber goods. In these trades there are also several firms whose capital may be estimated at 1,000,000*l.* and more, and many with means exceeding 100,000*l.*

'The enormous mass of raw material dealt with in this Lancashire district and the magnitude of the capital employed will serve to show the pre-eminent position occupied by the County Palatine in the manufacturing industry of the United Kingdom, and to prove incontestably that it above all others is entitled to a first place as a jewel in the English Crown.'

COTTON-SEED OIL. (See COTTON, vol. i. p. 954, and COTTON SEED, vol. i. p. 963.) For a long period the seed of the cotton plant was almost entirely neglected, but of late years a very important manufacture, the extraction of the oil, has been carried on in the cotton-producing states of America.

The cotton of commerce is, as is well known, a vegetable hair, covering the entire surface of the seed. This is separated by the use of the cotton gin (see COTTON GIN, vol. i. 961), and the seed, still covered with a cotton lint, is prepared for the expression of the oil.

This is effected by a repetition of a series of ginnings. The first process, the seed being clean, is that of hulling by a heavy cylinder, provided with knives that pass between teeth so close together that the seeds are broken into several pieces. The cracked seeds pass from the huller to a revolving sieve, or separator, that allows the nuts to fall into a trough, but retains the shells. These shells are either used for fuel, or prepared as a manure. The nuts go from the separator to a reciprocating sieve, which passes the pure nuts through it, but retains the few shells that were not separated, and sends these back to the separator for a second sifting. The nuts are then passed between two heavy iron rollers of great force, and are pressed into thin flakes, making a meal of yellowish-green colour. This meal is placed in iron tanks about 4 ft. in diameter and 15 in. deep. These are double, the inner vessel being surrounded by steam at a pressure of 35 lb. to the inch. The meal is stirred and

heated, being dry, for five minutes. This dry heat frees the oil from its envelope. The meal is then scraped into strong sacks about 2 ft. long and 10 in. wide, and placed between boards hinged together as the covers of a book are. Several of these sacks are then piled under a hydraulic press of great force, and squeezed for five minutes; they are then passed to a second and heavier press for the same length of time, and then to a third press. The oil runs from the presses to a tank and settles during 12 or 24 hours, and is then clarified. The best way of clarifying cotton-seed oil is to treat it with sulphuric acid, and afterwards with steam in an agitator constructed of wood lined with lead. After introducing, say, 600 gallons of oil, the agitator is set in motion, and 28 lb. of oil of vitriol are added by means of a perforated leaden trough, so as to spread it as a shower over the whole surface of the oil. The time employed in the addition of the acid should not be less than 30 minutes, and the agitation should be continued for 8 hours. It is then allowed to stand for 10 hours, the acid drawn off, and the oil pumped into a steaming tank of iron. It should then be steamed for 3 hours with ½ in. steam pipe, at 20 lb. pressure. This effects its purification. It is allowed to stand, and eventually, the water produced by the steam being separated, it is stored in tanks lined with lead. The cake of cotton-seed meal which remains is taken out of the sack and stood on its edge in a rack to dry during three or four days. The cakes are then packed in strong sacks or are broken up and ground into meal again to ship in bags. This is sent to England for cattle food, and as a fertiliser; but some is sold in the United States as a fertiliser. A ton of seed produces about 20 gallons of oil. The crude oil thus made is sent to refiners in New Orleans, Cincinnati, and New York. It has a yellow colour and a sweet taste of nuts. It is used crude for painting, and mixed with lard oil for lubricating. It is also mixed with some lighter oil or spirit for miners' lamps, for which its non-explosive quality makes it valuable. When refined it is difficult to tell all its uses. It is mixed with many other oils and passes for them.

COTTON, SILICATE OF. This modification of iron-slag, known as 'slag wool' or 'hair slag,' is attracting the attention of engineers. An architect in Berne, Mr. JAHN, describes its physical condition as being that of spun glass. It consists of fine hollow tubes, frequently 40 centimètres long, filled with air. It is the property which this possesses of holding a large quantity of air which makes it valuable as a non-conductor. As such it is not only adapted for use as a covering for steam-pipes, but it is of great efficiency as a stuffing for sound-proof walls and flooring. In this way it has been made use of for a couple of years in Zurich, and has been adopted by builders in Berne. It has been objected to as giving rise to the emission of free sulphuretted hydrogen, and to be objectionable as filling the atmosphere with fine penetrating particles. Walpert, of Kaiserslautern, however, affirms that though the silicate contains sulphur, in proportion to the sulphur contained in the iron ore, yet under ordinary circumstances the amount of moisture and carbonic acid in the air will not be sufficient to cause the evolution of any perceptible quantity of deleterious gas. Qualities of slag will vary as they decline from the normal proportions of 56 parts silicic acid, 30 calcium, 14 alumina. The blast-furnaces at Osnabrück and Zwickau were among the first to prepare the 'Schlackenwolle,' by sending the blast-air or steam through the melted slag; but it is now made in many places. That produced in the Austrian works was lately the subject of a paper read before the Vienna Society of Arts by A. GRÖGER, who pointed out not only the qualities already enumerated, but its incombustibility. A further use was indicated: as it will absorb six times its own weight of water, it has been suggested that it could be adapted to the manufacture of dynamite.

This 'slag wool' has been long known in this country. The editor has some very fine samples of the wool made, many years since, by Mr. SAMUEL BLACKWELL at the Ynescedwin Works in Glamorganshire. Even earlier than this it had been produced in the British Iron Works.

COTTON WASTE, at one time almost always rejected, is now of considerable value. It is the collected sweepings of the card room. Large heaps were formerly suffered to accumulate until it fermented, and it was then spread over the land. After that, cartridge-paper makers bought it at 2*l*. to 4*l*. per ton; and means were found to bleach and tear it up, in order that it might be respun and woven, and now there is a trade of 14,000,000 cwt. per annum, giving employment to 500 dealers, and the refuse of this is then sold for engine cleaning, and finally to the paper maker.

COVELLITE or **COVELLINE.** A pseudomorph of covellite after galena (cantonite) has been found as a Cornish mineral. In Miss CARNE's collection at Penzance a specimen labelled 'Copper ore with the fracture of galena from Huel Falmouth' has been found to be covellite. Analysis gives—

Copper	64·0
Iron	3·5
Lead	3·25
Sulphur	25·0
Sulphuric acid	1·25
Silver and iron	3·0
	99·55

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CRIN VEGETAL or **VEGETABLE HORSEHAIR.** The fibre of the leaves of the dwarf palm, *Chamærops humilis*.

CUTCH. (Vol. I. p. 1014.) Of this variety of catechu our importations were in 1875—

	Tons	Value
From British India	5,764	£139,971
,, other Countries	7	179
Total	5,771	140,150

and we exported in 1876, 2,862 tons, valued at 71,098*l.*

Of cutch and gambier our imports since 1873 have been—

	1873	1874	1875	1876
Tons	20,512	21,032	28,845	26,677
Value	£684,188	£523,760	£741,255	£613,992

CYLINDERS, ELECTRO-COPPERED. *On their Employment for Printing on Stuffs.* By TH. SCHLUMBERGER.

'During the last thirty years repeated attempts have been made in England to replace the solid copper and brass cylinders used in printing-mills by cylinders of cast iron covered with copper by galvanic deposit. These attempts have not been attended with the success that was anticipated, and the system has fallen into comparative disuse.

'In 1871 M. THEODORE SCHLUMBERGER presented to the Société Industrielle de Mulhouse a note on the employment of cast-iron coppered cylinders, and in March last M. GUSTAVE SCHAEFFER reported to the society—which had offered a prize for the best essay on the subject—the progress made up to that time.

'Neither the note of M. SCHLUMBERGER nor the report of M. SCHAEFFER are encouraging. The advantages are sufficiently great to induce perseverance; but the serious difficulties lead to the conclusion that further experiments should be undertaken from a new starting point. The copper and brass cylinders employed in a printing-mill represent a large capital. A new roller weighs between 1 and 2 cwt., the metal costing 2*s.* to 2*s.* 6*d.* per lb., and it can only be employed until, having been successively turned off and re-engraved, its weight is reduced to about ½ cwt. Each re-engraving lessens the weight by about 5 lb., and the diameter by somewhat more than the depth of the previous engraving. Sometimes, when adapting a roller to a given pattern, or pairing it with another to a given design, much more than this has to be turned to waste. Could cast iron be used as the foundation of these rollers, the saving in capital sunk in these machines would be obviously great. The raw metal would cost less than 1½*d.* per lb., and, when prepared to receive the copper coating, little more than 3½*d.* per lb.

'Since 1864 M. LOUIS HUGUENIN has coppered a number of rollers which have been engraved five or six times without any inconvenience. M. SCHLUMBERGER asserts that a positive advantage was gained each time the rollers were put into the coppering vats, because the imperfections on the surface of the copper disappeared. He estimates the cost of a cast-iron roller of ordinary dimensions at 4*l.*, and the cost of each re-coppering at from 8*s.* to 16*s.*—a price which is capable of reduction.

'The difficulties, on the other hand, are serious. In the first place the saving of cost is less than appears from the estimate of the saving of so many pounds of copper, from the fact that the electrotype copper costs at least five or six times as much as the commercial copper ordinarily used. Next, the adherence between the cast iron and the copper is not sufficient to prevent the latter from being injured under great pressure, and sometimes becoming laminated and loosened from the iron. Lastly, a cast-iron coppered roller is more difficult to repair than a solid copper or brass one. When one of the latter gets injured the place is plugged, or the surface burnished up and engraved; with a cast-iron cylinder, however, these processes are difficult, for plugging is attended with the danger of breaking through the coat and leaving the

iron exposed, by which the colours or the mordants are altered, while burnishing causes the copper to dilate and destroys its adherence to the iron.

'The process in these experiments was as follows:—After the surface has been turned up true in the lathe, the cast-iron roller is cleansed of grease by a strong alkaline solution and washed with an abundance of water, all traces of oxide being removed with a fine file. When this is accomplished the metallic surface is brilliant, and great care must be taken to prevent the moisture of the breath or of the fingers from coming in contact with it. The cleansed and polished roller is then plunged in an alkaline copper bath, and left during twenty-four hours under the influence of an electric current produced by five or six voltaic cells, until the whole surface of the cast iron is covered with a thin but well-adhering skin of copper. This alkaline bath may be composed as follows:—In 12 parts of water dissolve 1 part of sulphate of copper; in 16 parts of water dissolve cyanide of potassium, 3; carbonate of soda, 4; sulphate of soda, 2 parts. The two solutions are mixed after the salts are completely dissolved. Another alkaline bath is composed thus:—Water, 10; ammonia, 3; acetate of copper, 2. Water, 16; cyanide of potassium, 3; of soda, 4; sulphate of soda, 2.

'After removal from the alkaline bath the roller is washed and rubbed with rotten stone. If the iron in any place shows through the film of copper, the roller is returned to the bath until the entire surface is covered. This first coat should be perfect, but as thin as possible. When that result is obtained the roller is well brushed, washed, and rinsed in slightly acidulated water. It is then plunged quickly into an acid bath of sulphate of copper, in which it is left until the deposit of copper is sufficiently thick, being turned partly round each day, so as to insure an even deposit. With the current of four elements, and at a moderate temperature, three to four weeks are required to effect a deposit of $\frac{2}{3}$ of a millimètre in thickness.

'The strength of the solution of sulphate of copper is represented by 20° Baumé, in which 1 quart of sulphuric acid is added to every 300 quarts of solution, to render the bath more conducting, and to assist the dissolution of the scrap copper thrown in to keep up the strength of the bath.'

D

DALLEIOCHIN. (*Quinine Green.*) This is prepared as follows:—

Sulphate of quinine	. . . . .	10 parts
Water	. . . .	1,000 ,,
Liquid chloride of lime	. . . . .	134 ,,
Hydrochloric acid	. . . . .	35 ,,

These substances are allowed to react upon one another, and 125 parts of liquid ammonia are added. A greenish resinous matter is thus precipitated, which is collected upon a filter. This green is insoluble in water, benzol, or ether, but it dissolves in alcohol, wood spirit, and glycerine. Acetic acid turns it to a blue shade, and mineral acids dissolve it with a blue colour.

The alcoholic solution diluted with water dyes silk a green, which retains its tone by artificial light. Wool is dyed like silk. Cotton requires to be animalised with albumen. For calico-printing the Dalleiochin is mixed with albumen, and the colour fixed by steaming.

DAMMAR GUM. (Vol. ii, p. 8.) Mr. E. H. Beatley has introduced a process of mounting microscopic objects in Dammar which is free from most of the objections raised against this gum resin. He thus describes his process:—

'Having fixed my metal table a sufficient height above the flame of the spirit lamp (say about 2 in.), I place my slide on the copper plate, with the object put in the right position for mounting, and the glass cover on top; this I let warm for about two or three minutes; then (having previously warmed the tube of dammar, which has the effect of making it much more fluid) I drop a small quantity on the slide, in such a manner that the edge of the medium shall come in slight contact with the glass cover: capillary attraction causes the dammar (which is now very liquid) to gradually flow under the cover; if air bubbles appear around the object they must be removed by slight pressure and the aid of a heated needle. If the object is not flat, and raises the cover, a bullet placed on the top will keep it down. The above operation ought to take from ten to twelve minutes. Having proceeded thus far, I remove the spirit lamp from under my table, and let the slide gradually cool. When cold, the dammar is quite hard, and the cover firmly cemented. I now (with an old pocket knife) remove the superfluous dammar, wash the slide with a camel-hair brush dipped in turpentine, and then again with the same sort of brush, only using soap and water,

Having thoroughly wiped dry the slide, I finish with a ring of 'black japan varnish,' although I believe asphalte will do quite as well, and finally I label and put away in my cabinet; the whole having been completed in less than half an hour. Failures most likely would occur from one of the following causes:—Too great heat, thereby making the dammar boil under the cover, which would have the effect of destroying the object—the only remedy would be to at once remove or lower the flame of the lamp; too little heat, the result of which would be that the dammar would not harden when cold, and air bubbles; these are only got rid of by watching and carefully pressing the cover, and, if that will not remove them, by very gently lifting the cover so as not to disturb the object, and introducing a drop more dammar from the tube, which will no doubt prove effectual. Experience alone can properly determine the causes of failure, and enable the operator to judge the exact time to keep the slide heated; this any one can easily do after half a dozen attempts.'—*Scientific Gossip.*

A dammar varnish for mounting microscopic objects is also given in the article to which reference is made.

DAMMAR VARNISH, ELASTIC. (See DAMMAR GUM, or DAMMAR RESIN, vol. ii. p. 5.) An elastic flexible varnish for paper, which may be applied without sizing it, may be prepared as follows:—Crush transparent pieces of dammar into small grains; introduce 40 grains into a flask, pour on it about 6 ounces of acetone, and expose the whole to a moderate temperature for about two weeks, frequently shaking. At the end of this time pour off the clear saturated solution of dammar in acetone, and add to every four parts of varnish three parts of rather dense collodion; the two solutions are mixed by agitation, the resulting liquid allowed to settle, and preserved in well-closed phials. This varnish is applied by means of a soft beaver-hair pencil, in vertical lines. At the first application it will appear as if the surface of the paper were covered with a thin white skin. As soon, however, as the varnish has become dry, it presents a clear shining surface. It should be applied in two or three layers. This varnish retains its gloss under all conditions of weather, and remains elastic.

DATOLITE. (Vol. ii. p. 9.) An elaborate description of this boro-silicate of lime, found at Bergen Hill Tunnel, is given by E. S. DANA.—SILLIMAN'S *American Journal of Science and Art*, No. 4, p. 16.

DAUBREITE. An oxychloride of bismuth. M. DOMEYKO gives the following composition:—

Sesquioxide of bismuth	72·60
Sesquichloride of "	22·52
Water	3·84
Sesquichloride of iron	0·72
	99·68

This mineral is an earthy mass of a greyish white, with a great number of crystalline lamellæ of a nacreous lustre. Its hardness does not exceed 2 to 2·5, and its specific gravity 6·5.

DELESSITE. (Vol. ii. p. 13.) In New Caledonia a mineral is found which is closely allied to Delessite. It usually fills the cavities in the trap rocks. It is green, soft, fusible at the edges, and slightly soluble in hydrochloric acid. Analysis gave—

SiO^2	Al^2O^3	FeO	CaO	MgO	H^2O	
40·53	6·95	12·50	0·52	14·15	13·10	Gangue 2·37

H. How, *Philosophical Magazine*, xxxvii.

DESICCATION. (Vol. ii. p. 14.) See CALICO-PRINTING in this Supplement.

DETECTOR OF VARIATION IN PRESSURE OF GAS. This apparatus consists of an alarum, which is brought into action by an electric battery whenever the pressure exceeds a certain desired amount.

The arrangement is as follows:—A glass vessel, which admits of being completely closed, has a certain quantity of the protosulphate of mercury in solution placed in it. A smaller tube of glass, open at either end, is passed through the cover of the larger vessel down into the solution, and the junction made air tight. The liquid, of course, stands at the same level in each. Into the tube is placed a carbon plate, which is immersed in the solution, and a zinc plate, which is kept a short distance above the fluid by means of a small knob. These are connected with an electrical alarum. Through the cover of the larger vessel, fixed in a hole, is a tube of caoutchouc in communication with the gas meter, and through another hole is passed one arm of a siphon, which allows of the escape of gas when the pressure is too high. Any increase of pressure forces the liquid up the tube until it covers the zinc. An electric current is thus generated, and being connected in the usual way with the alarum, it is of

conese ring. It is said this apparatus has been used by the Société d'Emulation of Rouen, who have rewarded the inventor, M. LAUNAY, who has been for a considerable period Controller of the Paris Gas Company.—SAWARD'S *American Coal Trade Journal*, December 22, 1875.

DETONATION. See EXPLOSIVE COMPOUNDS.

DEXTROSE. A compound prepared from cane sugar by the action of sulphuric acid, and purified by crystallisation from alcohol and from water. Its composition when dry is $C^6H^{12}O^6$.—CORNELIUS O'SULLIVAN, *Journal of the Chemical Society*; see SCHEIBLER, *Deut. Chem. Ges. Ber.* vii.; and M. L. BONDONNEAU, *Comptes Rendus*, lxxxi.

DIABASE. (Vol. ii. p. 18.) Titaniferous iron, magnetic iron ore, and apatite are usual constituents of this mineral, and carbonate of lime is often present. Diabase forms beds and veins in the older rocks of Devonshire, in Norway, Westphalia, in the Hartz, &c.

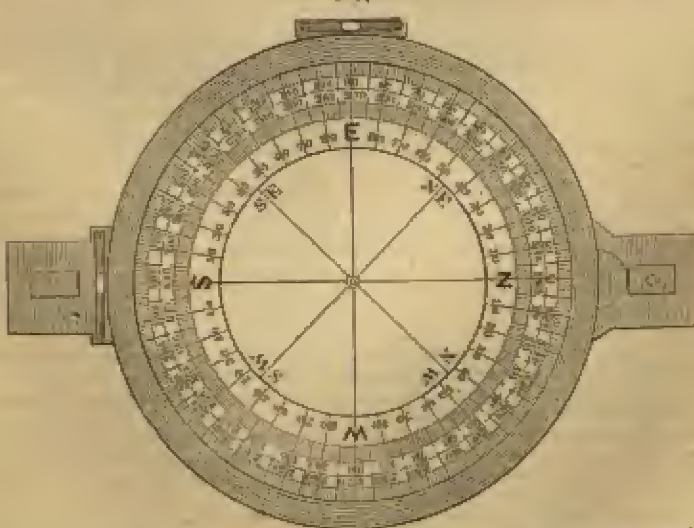
For excellent analyses of several kinds of diabase, see WATTS'S *Dictionary of Chemistry*, 2nd Supplement.

2316

DIALLING. The following particulars on the subject of Mine Surveying and Plotting gives an idea of the method as more especially adopted in the mines of Cornwall and Devon. But they are, in the main, applicable to the mines of any other district, differing only in a few unimportant details from any of them.

The instrument commonly used in mine surveying, and the most useful for general work, is the circumferentor (*figs.* 2316 and 2317). It consists essentially of a horizontal circular plate with a graduated circle of degrees numbered from 0° to 360°, and a vernier, by which these primary divisions are subdivided to single minutes. With the theodolite usually attached, the acclivity or declivity of hills, as well as of diagonal shafts and undu-

2317



lating excavations, may be obtained by this instrument. They are now made for either left- or right-hand readings, but it will be advisable uniformly to adopt the

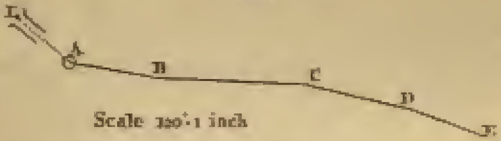
graduated figuring of the inner circle of the raised rim of the dial plate for the recording degree.

To make the subject of mine surveying as comprehensive as possible, it is divided into seven sections.

SECTION I. *Dialling with the Magnetic Needle.*—Assuming that a dial of the above description is employed (*figs.* 2316 and 2317), the operator in commencing a survey fixes the tripod firmly, and then, guided by the spirit levels, carefully adjusts the instrument, either by the ball and socket joint, or the adjusting screws, until the bubbles are centred. The dial plate is then turned around, until the south end of the needle (always distinguished) settles at 0° or 360°. Should the needle be sluggish, a gentle tap to the plate will cause a quivering, and facilitate its progress to its proper position. Having clamped the instrument securely to the tripod, an angle can now be taken in any required direction, by moving the sights around with the large thumb-screw, A (*fig.* 2316). There is a horizontal cog arrangement which admits of this being done without interfering with the circular plate. Having taken the observation, the degree on the inner graduated circle opposite the arrow on the vernier *scale* is recorded, together with the minutes which may be indicated by the same scale. Some practitioners read off the angle recorded by the north end of the needle, the movable sights being previously fastened at zero. But inasmuch as the above method should be adopted in dialling without the needle, and being equally as expeditious and more accurate in taking fractional parts of a degree, the advantage of uniformly observing it is apparent.

Example I.—Let A (*fig.* 2318) represent a shaft and B C D E a subterraneous excavation in a northerly direction from it, the bearings of which is required. Having made sure that there is no iron within a radius of six yards, the dialler fixes his instrument at B, to command two drafts. The plate is put into the position before described, and a back observation taken to A, and the degree indicated by the arrow in the vernier (which in this case, being a northerly drift, will be on the north side) is the direction of A B. The dialler then reverses his position, and takes a fore observation to C; the degree is read off as before, and this gives the course of B C.

2318



Scale 120'-1 inch

The next position for the dial is at D, the object at C being allowed to remain until the angle D C is determined. The previous operation to ascertain the direction of D E is repeated and the survey terminates. Some diallers check all drafts by fixing at each separate station, and taking back observations as well as foresights; but this necessitates double the amount of fixing, and is not necessarily more accurate. In some very intricate surveys a more speedy plan of verification is by dialling backwards from the forehead.

SECTION II. *Dialling without the Needle.*—It is well known that the magnetic needle is susceptible to the influence of iron, and even to ferruginous substances, and is consequently rendered unreliable by its presence. Serious errors having been from time to time fallen into by the counter attraction this offers, a system was devised by which the magnetic needle could be dispensed with after the first departure or a datum line obtained. The dial is carefully fixed out of the influence of iron in the manner already described, and the movable sights directed towards the objects stationed at the commencement of the survey. This should be a 'candle rest' with spirit levels, and adjusting screws, mounted on a tripod, of precisely the same size and description as that on which the dial stands. The angle which the index or vernier records with the circular plate is then observed, and the dial unclamped and removed to the position occupied by the candle rest, and it is transferred to the dial tripod. The movable sights are kept in the same position, and the dial plate moved around on its axis, until the candle at the first station of the dial is bisected. The circular plate is then rigidly clamped by the screw B (*fig.* 2316), and the instrument is ready to take an angle independently of the needle.

Whatever departure the needle may show from the north point, it is due to attraction, for, provided proper care has been exercised in the operation, the dial plate will correctly indicate the line of magnetic meridian, and virtually supersede the needle throughout the whole survey. Occasionally the whole dialling may be verified by

the last draft being out of the influence of iron, for if the south point of the needle corresponds with that on the circular plate its correctness is demonstrated.

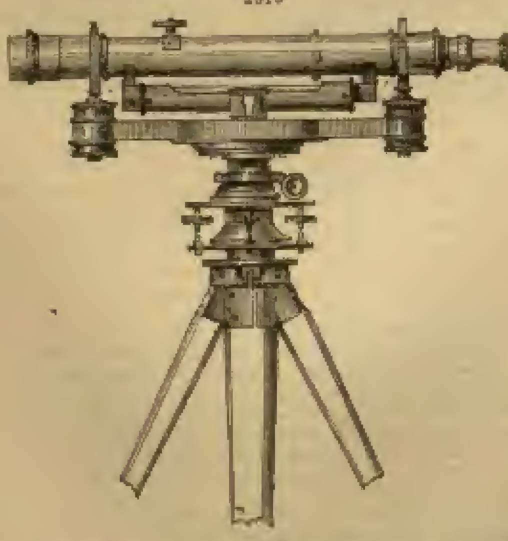
In conducting a survey without the use of the needle, the instrument must be fixed at each respective station, and fore and back sights be taken alternately. The operation will be rendered clear by the following example and a reference to *fig.* 2318.

Example 2.—The direction and distances of the subterraneous drift, A B C D E, containing iron rails and pipes, is required. To obtain a datum line the dial is fixed in the recess I, or if this is impracticable, a section of the rails and pipes must be removed. The instructions previously given having been strictly observed, the sights are directed to the candle rest at A, and the degree (say 40°) carefully noted, but not permanently entered. Reversing the position of the instrument and candle rest, the dial plate is moved around, with the sights still at 40°, until it bisects the candle now at I. This gives the datum line I A. The plate is then securely fastened, and the sights directed to B, which the vernier shows to be 10° distance, by measurement 30 feet. The dial is then carried forward to the next post of observation, B, the tripod on which it stood being allowed to remain undisturbed, for fixing the candle socket on, and with the sights still retained at 10°, the whole instrument is moved bodily around, until the perpendicular hair cuts the candle at A. This back observation being taken to keep the line of the magnetic meridian only, the angle is not recorded. The candle rest and tripod is now advanced to C, and the rack work controlling the movable sights of the dial brought into operation for ascertaining the angle from B to C, which by reference to the vernier we find is 1°, distance 50 feet. The position of the instrument and candle rest is again changed, and the preliminaries being attended to, the course from C to D is determined; this is 15° 35′, distance 35 ft. 6 in. We proceed in the same way to the station D, and get the direction of D E, which is 90° 45′, distance 20 ft. 0 in. This is the termination of the excavation. An opportunity may now be afforded, and the dialler should invariably avail himself of it, for testing the correctness of the survey.

This system, technically called 'blind dialling,' is equally applicable to underlie shafts and sumps, containing pumps or other iron. In this case the theodolite (see D, *fig.* 2316), furnished with most modern dials, is brought into use. The index side of this instrument is graduated from 0° to 90°, both right and left, therefore the elevation or the depression can be taken with equal facility. On the opposite side the perpendicular and underlie of every degree to a 6-foot length is registered, but in important surveys the degree

2320

2319



only should be noticed, because reliable mathematical tables are procurable, where the perpendiculars and bases are marked out to the thousandth part of an inch.

Strict care should be exercised in levelling the quadrant, and this may be readily done by fixing the arrow on the index side at zero, and bringing the bubble of the spirit level to the centre. In dialling a shaft a datum line is obtained as before, and the instrument fixed to command an up or down observation. The telescope or the quadrant sights are directed towards the object by working the screw E (*fig.* 2316), and the angle made by the inclined plane with the horizon, and also with the magnetic meridian, must be observed. At each successive station in the shaft, fore and back observations must be taken alternately, precisely the same as in the horizontal survey just gone through.

SECTION III. *Levelling.*—As already stated, the altitude or depression of any point may be ascertained by means of the theodolite attached to the circumferentor, and for subterraneous work no other need be substituted. It may be used also for surface levelling either by taking the angles of elevation or depression, or by fixing the quadrant at zero, and using the instrument as a spirit level. For long sights the former method, through the curvature of the earth and refraction, is incorrect, and should not be resorted to if great nicety is required.

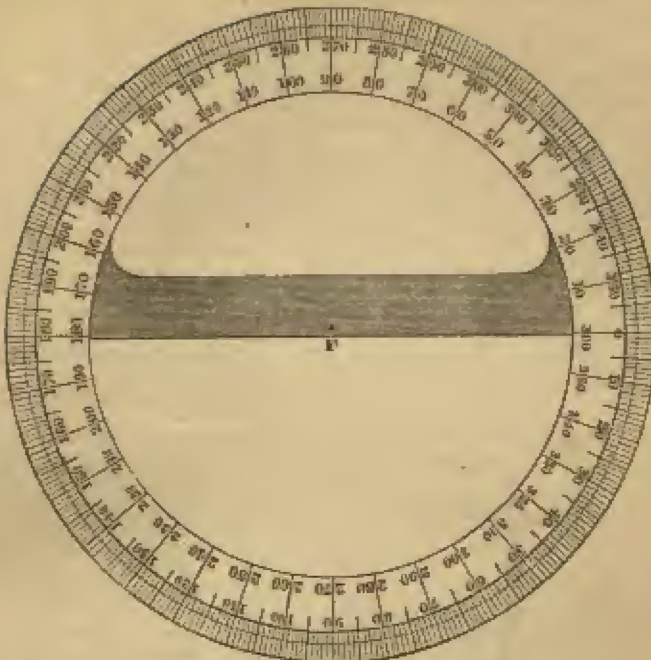
The levelling instrument proper (*fig.* 2319) consists of a long tube with a spirit level, and a telescope with finely divided vertical and horizontal lines, working on a vertical axis which is capable of the most perfect horizontal adjustment. This, in conjunction with a rectangular telescopic levelling rod, having a scale of feet and decimal subdivisions painted very distinctly on it (see *fig.* 2320), together with a Gunter's chain and arrows, is all that is required. Suppose the altitude of any point has to be ascertained. The instrument is fixed at any convenient situation, to command a back sight to the staff at the commencement of the line of operation and a fore sight to the next station; the difference between the staff readings will be the difference of the level of the two points. This process is repeated to the end of the line or the summit of the hill, and a record made as follows from A to B:—

Backwards.			*Forwards.*	
Reading of Staff at	A	6·70	1·60	Reading of Staff at 1
" "	1	13·20	2·62	" " 2
" "	2	15·63	1·25	" " 3
" "	3	9·50	4·04	" " 4
" "	4	10·39	3·55	" " B
		55·42	13·06	
		13·06		
		42·36		

42 ft. 4 in. is the height, therefore, of B above A.

SECTION IV. *Plotting Surveys.*—This operation is performed with a protractor divided into degrees similar to the circumferentor. *Fig.* 2321 represents one of the kind generally used, and it is graduated so as to correspond with the dial described. By this instrument the angles taken in any survey may be repeated on paper. A meridian line is assumed in any direction that will be most suitable for the work, and the straight face of the parallel rib in the centre of the protractor placed so as to coincide with the line. Suppose the angles formed by the subterraneous drift (*fig.* 2318), together with their respective lengths, have to be plotted. We commence by drawing a straight line to represent the magnetic meridian *north* and *south* (*fig.* 2322). The meridian line of the protractor (*fig.* 2321) is carefully laid on this, with 0° towards *north*, and a mark made at the centre of the instrument F, at 270° and at 90°, to obtain a right angle, which will represent the other cardinal points. We proceed now to mark off the degrees given above, which may be distinguished by figures or letters. When this is complete the protractor is removed, and by means of a parallel ruler B and F (*fig.* 2322) are brought into line; this gives the direction of the angle A B. The ruler is carefully rolled to any part of the paper on which it may be decided to commence the plotting, and having determined the size of the scale, 30 ft. is measured by the compass, and this length, drawn along the edge of the parallel ruler, represents the course of the drift from A to B. C and F (*fig.* 2322) are then connected in a similar manner, and the ruler moved to B; the length (50 ft.) corresponding with the scale, is then added on to B (*fig.* 2318), and the direction of B C represented. The ruler is then applied to D (*fig.* 2322), and its direction towards F (*fig.* 2322) is the angle from C to D (*fig.* 2318); the measurement (35 ft. 6 in.) is joined to B, and the drift from C to D indicated. The operation is repeated in reference to E, and the line added on, according to its measurement (29 ft. 9 in.), completes the work.

2321



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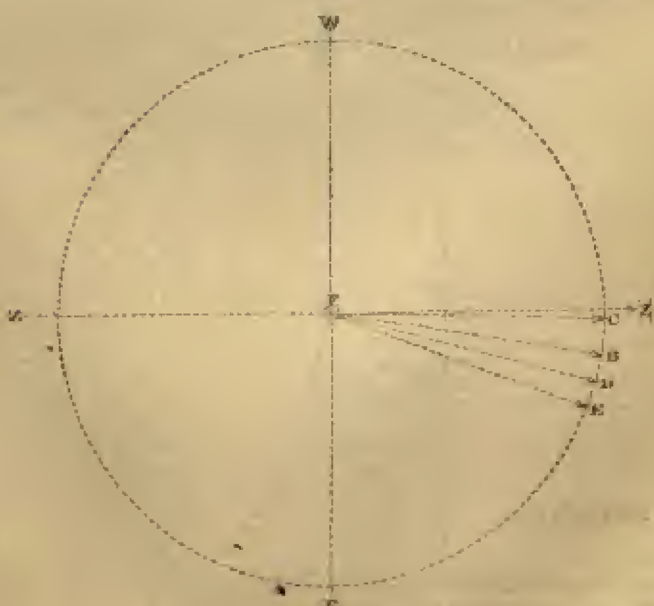
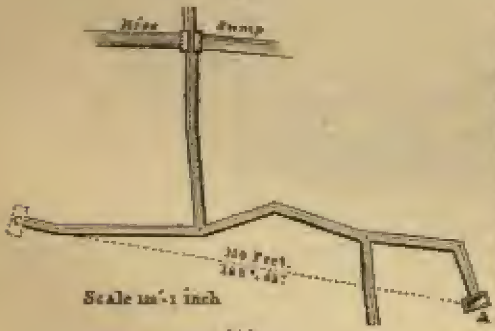


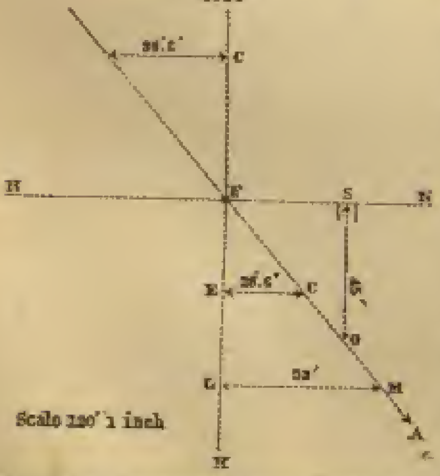
The following subterraneous survey is given as an additional example, and, at the same time, as an illustration of the method of keeping surveying books:—

1	2	3	4	5	6
Drafts	Angles	Elevation	Depression	Distances	Remarks
	° ′			ft. in.	
1	250·30	—	—	20 6	From centre of perp. shaft.
2	181·15	—	—	35 0	To crosscut on right.
(1)	84	—	—	16 6	In do.
(2)	80	—	—	12 6	To forebreast of do.
3	196	—	—	30 6	Back to main drift.
4	162	—	—	25 8	To crosscut on left.
(1 a)	260	—	—	35 0	In do.
(2 a)	270	—	—	28 6	To sump in sole and rise above.
(1 b)	6	—	42°	40 0	From sump-head to bottom.
(1 c)	179	50°	—	60 6	Up rise from sump-hea .
(3 a)	260	—	—	15 6	Continuation of crosscut to end.
5	180	—	—	60 6	Back to main drift.
6	187	—	—	12 6	To end of do., new dial mark hole in roof.

2323



2324



In plotting this survey we proceed as before, paying particular attention to No. 6 column. When (1 b) draft is arrived at, we must ascertain its true base before laying down the horizontal angle, because this being a ground plan, it would be manifestly erroneous to give the whole length of the draft. Its actual base or progression to the right of the crosscut, (1 a) (see *fig.* 2323), may be determined by the protractor. We draw a line as before, in this case to represent the horizon, H N (*fig.* 2324), and the protractor is laid on it, and the degrees of elevation and depression of the rise and sump respectively marked off at the same time. Then with a parallel ruler a line is drawn from F to A (*fig.* 2324)—that being the point where the degree was marked off—and 40 feet measured along it. Having previously obtained the perpendicular F K, the horizontal line is brought down to C; the distance from C to E will be the true base or progression of the sump towards the right. The inclination of the rise to the left is obtained in the same way, and these reduced measurements plotted according to the horizontal angle taken with the dial. The perpendicular of the sump and the vertical height of the rise may be

ascertained by measuring from F to B and from F to C respectively. This diagram also shows the method of determining the required depth of shafts and lengths of drifts to reach a given point.

Example 3.—Let F A (*fig.* 2324) represent a vein of lead ore. A perpendicular shaft is commenced at s, which is 40 ft. from F; at what depth will the vein be intersected? With a parallel ruler the perpendicular line is advanced to s; the distance from s to O will be the depth required.

Example 4.—Suppose F E (*fig.* 2324) to be a perpendicular shaft and F A a metalliferous vein, making an angle with the horizon of 49°, what length would the cross drift, L M, require to be, before the vein was intersected? We have simply to bring down the horizontal line to L, and measure from L to M, and this distance is ascertained. The practitioner is recommended to provide himself with proper traverse tables to verify all instrumental operations.

The plotted survey (*fig.* 2323) furnishes the mode of finding the corresponding spot at surface with any point of the excavation.

Example 5.—It is required to sink a shaft perpendicularly to communicate G with the surface. With the parallel ruler A and G are brought into relation, and the ruler rolled to F (*fig.* 2322). A pencil line is drawn along its edge of sufficient length to exceed the diameter of the protractor, and the degree (118° 45') ascertained by that instrument. The distance from A to G is then measured direct—this is 158 ft. If the circumferentor is now placed at A on surface, and the sights fixed at 188° 45', 158 ft. on this angle will give, providing the surface be level, the correct position of the shaft G.

SECTION V. *Trigonometrical Solutions.*—Every degree of the circumferentor, excepting the cardinal points represented by 360° and 180°, are departures from the meridian line, the magnitude of which may be determined by two methods. 1st. By mathematical instruments. 2nd. By trigonometry or by computation. *Fig.* 2325 illustrates the first mode. N S represents the meridian line, and A B a drift in a NW. direction; the divergence west and gain north may be measured from A to D, and from D to B respectively—in other words, its northing and westing be ascertained. As the concluding paragraph on plotting, together with *fig.* 2326, give a more extended view of this method, examples need not be multiplied. For various reasons this system of instrumental operation is not perfectly reliable in very important and lengthy surveys, for with the utmost care in plotting serious discrepancies may occur. The second method precludes the possibility of any such inaccuracies, and furnishes such an absolutely correct test, that the dialler is freed from the perplexity which would inevitably follow any uncertainty as to the accuracy of the work he may have been called upon to execute.

2325

Scale 30' = 1 inch

It would exceed the limits of this paper to convey even a rudimentary knowledge of trigonometry, neither is it absolutely essential that the ordinary miner should be acquainted with it. He need only be informed that he can get in most books on

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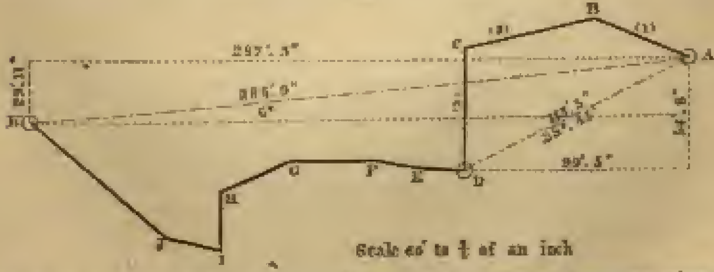

Scale 60' to ¼ of an inch

navigation traverse tables of the northing or southing, easting or westing, wherein the distance is extended to one hundred for every degree of the quadrant.

In practically applying this method it must be borne in mind that in surveys the

angles are ordinarily entered and reduced to bearings afterwards, if a trigonometrical solution is required.

We give the following as an example of converting angles into bearings: 44° is 44° E. of N.; 144° is 36° E. of S.; 316° is 44° W. of N.; 181° is 1° W. of S. A little practice will render this duty quite easy. We may now illustrate this method.

Example 6.—Let B, C, D, E, F, G, H, I, J, K, represent a subterranean excavation from bottom of the perpendicular shaft A (*fig.* 2320): required, the southing and easting of A D, and also the southing and easting of A K. Having reduced the angles into bearings, the particulars are tabulated as follows:—

Preparatory Table for A D.

No.	Angles	Bearings	Distances	Northing	Southing	Easting	Westing
	°	°	Ft.				
1	200	20 W. of S.	45	—	42·29	—	15·39
2	170	10 E. „ S.	58	—	57·12	10·07	—
3	90	East	60	—	—	60·	—
				—	99·41	70·07	15·39
				—	—	15·39	—
				Southing 99·41		54·68 Easting	

Preparatory Table for A K.

No.	Angles	Bearings	Distances	Northing	Southing	Easting	Westing
	°	°	Ft.				
1	200	20 W. of S.	45	—	42·29	—	15·39
2	170	10 E. „ S.	58	—	57·12	10·07	—
3	90	E.	60	—	—	60·00	—
4	184	4 W. „ S.	19	—	18·95	—	1·33
5	190	10 „	24	—	23·64	—	4·17
6	179	1 E. „ S.	36	—	35·99	·61	—
7	156	24 „	28	—	25·58	11·39	—
8	88	2 N. „ E.	26	·91	—	25·98	—
9	194	14 W. „ S.	24	—	23·29	—	5·81
10	220	40 „	80	—	61·30	—	51·42
				·91	258·16	108·05	78·12
				—	·91	78·12	—
				Southing 257·25		29·93 Easting	

The measurements given in the four last columns are obtained from traverse tables, and are in fact the products of the sines and cosines of the angles made with the meridian line. The first column in these tables is usually designated bearing lengths, and may represent feet, fathoms, or chains. The only thing to be observed is, that the same denomination must be given to the products in the northing, southing, easting, and westing columns. For instance, the bearing from A to B, *fig.* 2320, is 20° W. of S.—45 ft. We find the degree at the head of the table corresponding with this, and tracing down the column of 'bearing lengths' we come to 45. The measurements opposite this are the quantities to be entered. Particular care needs to be exercised as to which column the products or bases are to be contained in, but by observing the simple rule of entering the largest product under the last denomination of the bearing, all uncertainty as to its proper position will be obviated. Having obtained all the products in this way, and tabulated them as shown, we proceed to add them up, and subtracting the lesser from the greater of the cardinal points north and south, and also of east and west, the difference shows the excess of southing from A to D is 99 ft. 5 in., and of easting 54 ft. 8 in.; also that from A to K the southing or base gained in that direction is 257 ft. 3 in., and that the easting exceeds the westing by 29 ft. 11 in. A reference to *fig.* 2320, where this survey is platted, shows that the results obtained by arithmetical calculation are corroborated instrumentally

If it was required to sink shafts to come down on the points D and E, we should simply have to fix a circumferentor on the collar of the shaft A, and taking an observation due south 287 ft. 3 in., and then due east 29 ft. 11 in. from this station, the position of the shaft E would be determined. The exact situation of the shaft D is found by repeating the operations with the measurements arrived at in the table A D.

The survey is now reduced to two main lines or to the cardinal points south and east and their respective lengths ascertained, but though not absolutely necessary, it is occasionally desirable on account of obstructions, and for other reasons, to resolve these two into a single line direct to the spot, and also to reduce the two measurements to one. In this operation we have simply to get the hypothenusal distance by square root, and the angle by proportion. This may be accomplished as follows: the sum of the squares of the two sides are added together, and their square root extracted. As an example, we take the survey just computed, first from A to D:—

```
   Easting.                      Southing.
    54·68                          99·41
    54·68                          99·41
    -----                          -----
    43744                           9941
   32808                          39764
  21872                          89469
 27340                          89469
 ---------                      --------
 2989·9024                      9882·3481
                                2989·9024
                               ----------------
                               12872·2505(113·45 ft.
                               1                12
                           21) 28              ----
                               21               5·40
                          223) 772
                               669
                         2264) 10325
                                9056
                        22685) 126905
                               113425
                               ------
                                13480
```

The quotient, 113 ft. 5 in., is the direct distance, therefore, from A to D.

The hypothenuse of A E is found in a similar manner—

```
   Easting.                      Southing.
    29·93                         287·25
    29·93                         287·25
    -----                         ------
    89·79                         143625
   26937                         57450
  26937                        201075
 5986                         229800
 --------                     57450
 895·8049                     ----------
                              82512·5625
                                895·8049
                              ------------------
                              83408·3674(288·8
                              4                 12
                          48) 434              ---
                              384               9·6
                         568) 5008
                              4544
                        5768) 46436
                              46144
                              -----
                                292
```

The quotient, 288 ft. 9 in., is the measurement from A to E direct.

The angle of A D can be found by proportion as follows:—

```
         ft.  in.          ft.  in.
     If  99   5   give    64   8    what will 6 ft. give?
         12                12
       ----              ----
       1193               656
                            6
           1193)3936(3 ft.
                3579
                ----
                 357
                  12
           1193)4284(3 in.
                3579
                ----
                 645                    Answer 3 ft. 3 in.
```

The angle of A E is ascertained in the same way:—

```
      287·3     :     29·11     ::     6
        12              12
      ----             ---
      3447             359
                         6
            3447)2154(0·7·49
                    12
                 -----
                 25848
                 24129
                 -----
                  17190
                  13788
                  -----
                   34020
                   31023
                   -----
                    2997
```

Thus we have 3 ft. 3 in. as a quotient for A D, and 7·49 in. for A E. We have now simply to turn to a proper table appended to this article (Budge's 2nd), giving the bases corresponding with those quantities, and opposite that will be the degrees required. That answering to the former is 28° 45′, and to the latter 6°. A line now from A, 288 ft. 9 in. in length, on an angle of 6° east of south, will give the position of the shaft at E, and a line from A, 113 ft. 5 in. on an angle of 28° 45′ east of south, will determine the situation of the shaft D. Ten bearings with their respective distances have now been resolved into one final line and one measurement, both by computation and instrumental operation, and the example shows conclusively that with a fair knowledge of square root and proportion, and assisted by traverse tables to get the product of the sines and cosines, and a Budge's table to ascertain the angle in the manner described, the practitioner is in possession of all the arithmetical knowledge that is necessary to subject his surveys to the infallible test of trigonometrical solution.

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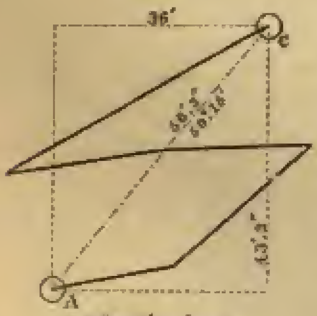

Scale 36′–1 inch

Before closing this section the following additional example is given, to show that fractions of feet and of degrees may be obtained, as these were purposely avoided in the survey just concluded. Suppose the subjoined bearings and distances represent the plotted survey (*fig.* 2327). It is proposed to sink a perpendicular shaft to communicate C with the surface: required the direct angle and distance from A to C.

Preparatory Table.

Draft	Bearing	Distance	Northing	Southing	Easting	Westing
	° ′	ft. in.				
1	10 30 W. of N.	20 6	20·1	—	—	3·8
2	40 45 W. „ N.	30 9	23·4	—	—	20·6
3	2 15 E. „ S.	24 6	—	24·5	·11	—
4	8 45 E. „ S.	27 9	—	27·5	4·2	—
5	28 30 W. „ N.	50 6	44·5	—	—	24·1
		—	87·10	51·10	5·1	48·3
		—	51·10	—	—	5·1
		Northing 36·0		—	Westing 43·2	

We proceed as before by extracting the square root of the sum of the two sides added together.

Northing.

36
36
216
108
1296

Westing.

43·2
43·2
86·4
1296
1728
186624
1296
3162·24(56·2
25
106) 662
636
1122) 2624
2244
380

The hypothenusal distance, therefore, is 56 ft. 2 in.

By the following operation the angle is found:—

ft. ft. in.
If 56 give 43 2 what will 6 ft. give?
12 12
432 518
6
432)3108(7·2
3024
84
12
1008
864
144

By inspection of the tables referred to, this quotient is represented by 50° 15′; a line therefore from A, 56 ft. 2 in. on an angle of 50° 15′ west of north, is the position of the proposed shaft C.

SECTION 6. *Magnetic Variation.*—The phenomena of a constantly changing magnetic meridian is so well known, that all careful diallers arrange their surveys with a view to any future variation that may occur, either by recording the exact deflection of the needle at the time the survey is made, or by at once reducing the angles to a true meridian and plotting accordingly. If, for instance, we are conducting a survey in 1870, we have simply to preface our entry of the diallings with a note, to the effect that the variation of the needle for this year is 23° west of north. It is advisable,

also, in making permanent plans of a mine to let the north point be distinguished by two lines, one representing the magnetic, the other the true meridian. In the annual correction of plans the declination of the needle for each year should be indicated by faint lines radiating from the working centre, and the plotting be done from them, or the additions made will be invariably erroneous. There is an appreciable diurnal deflection of the needle, but for ordinary work it need not be regarded. The dialler may now personally ascertain the annual magnetic variation of succeeding years by planting a permanent peg at any convenient spot, and fixing the circumferentor exactly over it—directing the sights 23° E. of magnetic N. A firm peg driven in about 100 yards distant will represent the true meridian at any future period.

SECTION 7. *Plans and Sections.*—1. *Surface Plan.* As its name indicates, this plan embraces all the principal points in the sett. The boundaries especially should be boldly distinguished, and the main hedges and roads defined. The direction and inclination of all known lodes and slides should also be delineated.

2. *Working Plan.*—What the chart is to the mariner so this plan is to the miner. It supposes that all the intervening ground is removed, and affords an unobstructed view of the actual course and extent of all the subterranean drifts, excepting those that may be immediately under the upper works. Fig. 2323 is part of such a plan.

This plan is rendered extremely useful both for measurements and for determining bearings, at a glance, if it is divided by faint-coloured lines into 1 or 2 inch squares, these lines being of course parallel with the cardinal points. The termination of each drift should be distinguished with a dot, and in the case of levels merging into each other, the colours employed should form as great a contrast as possible. A properly divided scale of feet or fathoms should not be omitted at the foot of the plan, and a 'reference' is generally serviceable.

3. *Longitudinal Section.*—This drawing exposes the sides of the various shafts and excavations, and has reference to lengths and depths only. Ore ground, stopes, slides, and cross lodes, may be shown on this plan, together with the entrances to cross drifts.

4. *Transverse Section.* This presents an end view of the mine to the observer. In it may be correctly represented, cross cuts, the underlie of shafts, sumps, and veins, and also the mouths of the successive longitudinal drifts.

In concluding this paper it may be well to add that a simple mode of treatment has been purposely adopted, and the more difficult problems intentionally omitted; it being considered advisable to make the subject as intelligible as possible to a class of individuals whose circumstances have not favoured a liberal education.

SECOND TABLE.—BUDGE'S.

Perpendicular Radius One Fathom.

Angle		Base				Hypothenuse			
Deg.	Min.	Fath.	Feet	In.	Decimals	Fath.	Feet	In.	Decimals
1		0	0	1	·2568	1	0	0	·0108
	15	0	0	1	·5710	1	0	0	·0171
	30	0	0	1	·8854	1	0	0	·0247
	45	0	0	2	·1998	1	0	0	·0335
2		0	0	2	·5143	1	0	0	·0432
	15	0	0	2	·8289	1	0	0	·0554
	30	0	0	3	·1436	1	0	0	·0684
	45	0	0	3	·4582	1	0	0	·0828
3		0	0	3	·7728	1	0	0	·0986
	15	0	0	4	·0882	1	0	0	·1159
	30	0	0	4	·4035	1	0	0	·1346
	45	0	0	4	·7189	1	0	0	·1544
4		0	0	5	·0328	1	0	0	·1757
	15	0	0	5	·3496	1	0	0	·1980
	30	0	0	5	·6664	1	0	0	·2171
	45	0	0	5	·9825	1	0	0	·2484
5		0	0	6	·2993	1	0	0	·2736
	15	0	0	6	·6168	1	0	0	·3024
	30	0	0	6	·9335	1	0	0	·3312
	45	0	0	7	·2505	1	0	0	·3636
6		0	0	7	·5672	1	0	0	·3960

Angle		Base				Hypothenuse			
Deg.	Min.	Fath.	Feet	In.	Decimals	Fath.	Feet	In.	Decimals
	15	0	0	7	·6841	1	0	0	·4298
	30	0	0	8	·2068	1	0	0	·4659
	45	0	0	8	·5212	1	0	0	·5026
7		0	0	8	·8402	1	0	0	·5400
	15	0	0	9	·1584	1	0	0	·5803
	30	0	0	9	·4788	1	0	0	·6192
	45	0	0	9	·7992	1	0	0	·6624
8		0	0	10	·1189	1	0	0	·7056
	15	0	0	10	·4393	1	0	0	·7531
	30	0	0	10	·7604	1	0	0	·7992
	45	0	0	11	·0808	1	0	0	·8474
9		0	0	11	·4031	1	0	0	·8971
	15	0	0	11	·7259	1	0	0	·9482
	30	0	1	0	·0485	1	0	1	·0008
	45	0	1	0	·3696	1	0	1	·0548
10		0	1	0	·6936	1	0	1	·1088
	15	0	1	1	·0176	1	0	1	·1664
	30	0	1	1	·3416	1	0	1	·2262
	45	0	1	1	·6692	1	0	1	·2859
11		0	1	1	·9954	1	0	1	·3476
	15	0	1	2	·3215	1	0	1	·4106
	30	0	1	2	·6484	1	0	1	·4750
	45	0	1	2	·9760	1	0	1	·5410
12		0	1	3	·3036	1	0	1	·6085
	15	0	1	3	·6326	1	0	1	·6775
	30	0	1	3	·9617	1	0	1	·7481
	45	0	1	4	·2914	1	0	1	·8202
13		0	1	4	·6210	1	0	1	·8939
	15	0	1	4	·9538	1	0	1	·9691
	30	0	1	5	·2857	1	0	2	·0459
	45	0	1	5	·6178	1	0	2	·1242
14		0	1	5	·9496	1	0	2	·2042
	15	0	1	6	·2838	1	0	2	·2857
	30	0	1	6	·6192	1	0	2	·3689
	45	0	1	6	·9570	1	0	2	·4535
15		0	1	7	·2888	1	0	2	·5400
	15	0	1	7	·6204	1	0	2	·6338
	30	0	1	7	·9670	1	0	2	·7174
	45	0	1	8	·3062	1	0	2	·8087
16		0	1	8	·6456	1	0	2	·9015
	15	0	1	8	·9858	1	0	2	·9961
	30	0	1	9	·3271	1	0	3	·0540
	45	0	1	9	·6695	1	0	3	·1902
17		0	1	10	·0126	1	0	3	·2895
	15	0	1	10	·3560	1	0	3	·3911
	30	0	1	10	·7063	1	0	3	·4941
	45	0	1	11	·0472	1	0	3	·5988
18		0	1	11	·3942	1	0	3	·7053
	15	0	1	11	·7420	1	0	3	·8135
	30	0	2	0	·0905	1	0	3	·9234
	45	0	2	0	·4204	1	0	4	·0352
19		0	2	0	·7916	1	0	4	·1487
	15	0	2	1	·1435	1	0	4	·2640
	30	0	2	1	·4965	1	0	4	·3811
	45	0	2	1	·8508	1	0	4	·5000
20		0	2	2	·2058	1	0	4	·6205
	15	0	2	2	·5622	1	0	4	·7434
	30	0	2	2	·9197	1	0	4	·8679
	45	0	2	3	·2783	1	0	4	·9942
21		0	2	3	·6262	1	0	5	·1224
	15	0	2	3	·9993	1	0	5	·2526

Angle		Base				Hypothenuse			
Deg.	Min.	Fath.	Feet	In.	Decimals	Fath.	Feet	In.	Decimals
	30	0	2	4	·3615	1	0	5	·3846
	45	0	2	4	·7251	1	0	5	·5186
22		0	2	5	·0809	1	0	5	·6545
	15	0	2	5	·4560	1	0	5	·7924
	30	0	2	5	·8234	1	0	5	·9323
	45	0	2	6	·1921	1	0	6	·0741
23		0	2	6	·5622	1	0	6	·2179
	15	0	2	6	·9336	1	0	6	·3638
	30	0	2	7	·3065	1	0	6	·5117
	45	0	2	7	·6807	1	0	6	·6617
24		0	2	8	·0565	1	0	6	·8138
	15	0	2	8	·4336	1	0	6	·9679
	30	0	2	8	·8120	1	0	7	·1242
	45	0	2	9	·1924	1	0	7	·2826
25		0	2	9	·5741	1	0	7	·4432
	15	0	2	9	·9574	1	0	7	·6059
	30	0	2	10	·3422	1	0	7	·7708
	45	0	2	10	·7287	1	0	7	·9380
26		0	2	11	·1167	1	0	8	·1073
	15	0	2	11	·5065	1	0	8	·2789
	30	0	2	11	·8979	1	0	8	·4528
	45	0	3	0	·2910	1	0	8	·6290
27		0	3	0	·6858	1	0	8	·8075
	15	0	3	1	·0824	1	0	8	·9883
	30	0	3	1	·4808	1	0	9	·1714
	45	0	3	1	·8810	1	0	9	·3571
28		0	3	2	·2831	1	0	9	·5450
	15	0	3	2	·6870	1	0	9	·7354
	30	0	3	3	·0928	1	0	9	·9283
	45	0	3	3	·5005	1	0	10	·1232
29		0	3	3	·9102	1	0	10	·3212
	15	0	3	4	·3219	1	0	10	·5220
	30	0	3	4	·7356	1	0	10	·7251
	45	0	3	5	·1513	1	0	10	·9308
30		0	3	5	·5692	1	0	11	·1384
	15	0	3	5	·9892	1	0	11	·3494
	30	0	3	6	·4112	1	0	11	·5625
	45	0	3	6	·8355	1	0	11	·7788
31		0	3	7	·2620	1	0	11	·9976
	15	0	3	7	·6907	1	1	0	·2192
	30	0	3	8	·1216	1	1	0	·4436
	45	0	3	8	·5550	1	1	0	·7068
32		0	3	8	·9906	1	1	0	·9968
	15	0	3	9	·4286	1	1	1	·1336
	30	0	3	9	·8691	1	1	1	·3696
	45	0	3	10	·3119	1	1	1	·6084
33		0	3	10	·7573	1	1	1	·8501
	15	0	3	11	·2053	1	1	2	·0949
	30	0	3	11	·6558	1	1	2	·3427
	45	0	4	0	·1088	1	1	2	·5937
34		0	4	0	·5646	1	1	2	·8477
	15	0	4	0	·9931	1	1	3	·1049
	30	0	4	1	·4842	1	1	3	·3653
	45	0	4	1	·9182	1	1	3	·6269
35		0	4	2	·4149	1	1	3	·8958
	15	0	4	2	·8846	1	1	4	·1660
	30	0	4	3	·3571	1	1	4	·4395
	45	0	4	3	·8326	1	1	4	·7165
36		0	4	4	·3141	1	1	4	·9969
	15	0	4	4	·7944	1	1	5	·2808
	30	0	4	5	·2772	1	1	5	·5619

Angle		Base				Hypothenuse			
Deg.	Min.	Fath.	Feet	In.	Decimals	Fath.	Feet	In.	Decimals
	45	0	4	5	·5650	1	1	5	·8591
37		0	4	6	·2550	1	1	6	·1638
	15	0	4	6	·7501	1	1	6	·4620
	30	0	4	7	·2476	1	1	6	·7549
	45	0	4	7	·7483	1	1	7	·0597
38		0	4	8	·2526	1	1	7	·3693
	15	0	4	8	·7602	1	1	7	·6831
	30	0	4	9	·2834	1	1	8	·0000
	45	0	4	9	·7861	1	1	8	·3214
39		0	4	10	·3044	1	1	8	·6467
	15	0	4	10	·8265	1	1	6	·9761
	30	0	4	11	·3522	1	1	9	·3096
	45	0	4	11	·8818	1	1	9	·6473
40		0	5	0	·4152	1	1	9	·9803
	15	0	5	0	·9525	1	1	10	·0956
	30	0	5	1	·4938	1	1	10	·6863
	45	0	5	2	·0392	1	1	11	·0113
41		0	5	2	·5886	1	1	11	·4009
	15	0	5	3	·1420	1	1	11	·7651
	30	0	5	3	·7002	1	2	0	·1338
	45	0	5	4	·2624	1	2	0	·5049
42		0	5	4	·8291	1	2	0	·8555
	15	0	5	5	·4002	1	2	1	·2086
	30	0	5	5	·9758	1	2	1	·5566
	45	0	5	6	·5705	1	2	2	·0496
43		0	5	7	·1411	1	2	2	·4476
	15	0	5	7	·7308	1	2	2	·8507
	30	0	5	8	·3254	1	2	3	·2591
	45	0	5	8	·9250	1	2	3	·6727
44		0	5	9	·5296	1	2	4	·0918
	15	0	5	10	·1393	1	2	4	·5163
	30	0	5	10	·7542	1	2	4	·9463
	45	0	5	11	·3744	1	2	5	·3820
45		1	0	0	·0000	1	2	5	·8234
	15	1	0	0	·6311	1	2	6	·2706
	30	1	0	1	·2677	1	2	6	·7257
	45	1	0	1	·9101	1	2	7	·1528
46		1	0	2	·5832	1	2	7	·6151
	15	1	0	3	·2122	1	2	8	·1105
	30	1	0	3	·8722	1	2	8	·5073
	45	1	0	4	·5382	1	2	9	·0514
47		1	0	5	·2105	1	2	9	·5731
	15	1	0	5	·8892	1	2	10	·0694
	30	1	0	6	·5742	1	2	10	·5734
	45	1	0	7	·2658	1	2	11	·0844
48		1	0	7	·9641	1	2	11	·6023
	15	1	0	8	·6692	1	3	0	·1273
	30	1	0	9	·3812	1	3	0	·6596
	45	1	0	10	·1003	1	3	1	·1991
49		1	0	10	·8265	1	3	1	·7462
	15	1	0	11	·5601	1	3	2	·3009
	30	1	1	0	·3012	1	3	2	·8631
	45	1	1	1	·0498	1	3	3	·4337
50		1	1	1	·8062	1	3	4	·0122
	15	1	1	2	·5690	1	3	4	·5987
	30	1	1	3	·3430	1	3	5	·1936
	45	1	1	4	·1236	1	3	5	·7970
51		1	1	4	·9126	1	3	6	·4091
	15	1	1	5	·7101	1	3	7	·0300
	30	1	1	6	·5164	1	3	7	·6529
	45	1	1	7	·3316	1	3	8	·2990

Angle		Base				Hypothenuse			
Deg.	Min.	Fath.	Feet	In.	Decimals	Fath.	Feet	In.	Decimals
52		1	1	8	·1500	1	3	8	·2474
	15	1	1	8	·9893	1	3	9	·6053
	30	1	1	9	·8322	1	3	10	·2720
	45	1	1	10	·6846	1	3	10	·9505
53		1	1	11	·5472	1	3	11	·6381
	15	1	2	0	·4107	1	4	0	·3360
	30	1	2	1	·3024	1	4	1	·0445
	45	1	2	2	·1950	1	4	1	·7636
54		1	2	3	·0995	1	4	2	·4937
	15	1	2	4	·0142	1	4	3	·2350
	30	1	2	4	·9403	1	4	3	·9876
	45	1	2	5	·8776	1	4	4	·7520
55		1	2	6	·8267	1	4	5	·5282
	15	1	2	7	·7876	1	4	6	·3165
	30	1	2	8	·7606	1	4	7	·1172
	45	1	2	9	·7458	1	4	7	·9308
56		1	2	10	·7441	1	4	8	·6570
	15	1	2	11	·7556	1	4	9	·5968
	30	1	3	0	·7801	1	4	10	·4497
	45	1	3	1	·8183	1	4	11	·3165
57		1	3	2	·8703	1	5	0	·1976
	15	1	3	3	·9365	1	5	1	·0932
	30	1	3	5	·0174	1	5	2	·0034
	45	1	3	6	·1131	1	5	2	·9287
58		1	3	7	·2241	1	5	3	·8697
	15	1	3	8	·3507	1	5	4	·8265
	30	1	3	9	·4933	1	5	5	·7994
	45	1	3	10	·6525	1	5	6	·7890
59		1	3	11	·7281	1	5	7	·7955
	15	1	4	1	·0211	1	5	8	·8194
	30	1	4	2	·2317	1	5	9	·8612
	45	1	4	3	·4604	1	5	10	·9212
60		1	4	4	·7077	2	0	0	·0000

J. H.

DIAMONDS. African, South. (Vol. ii. p. 10.) Diamonds were vaguely reported to have occurred on the banks of the Vaal and Orange rivers, in South Africa, for a considerable time past, but it was only within the last ten years that they have been known to exist in any parts in particular, or that any extensive workings have been wrought for their production.

About the year 1868 rumours existed in the Cape Colony and neighbouring States that certain travellers had made the discovery of diamonds in the country near the junction of the Vaal with the Orange River. Many tales are circulated, giving first one and then others the credit for this discovery; it is probable that the discovery was made by different parties independently of each other. One of these stories, which seems not improbable, is that a certain trader, in visiting a 'boer' (farmer) resident in these parts, found the 'boer' had collected a variety of interesting mineral specimens from the surrounding country, and feeling some curiosity, induced the 'boer' to part with them. On the trader going down to the more settled parts in the Cape Colony, and submitting his mineral specimens to a gentleman of some mineralogical knowledge, the latter declared the collection to contain diamonds.

However it may have originated, the rumour spread with marvellous rapidity that diamonds had been discovered, and most of the residents in the country commenced looking over their farms, perchance they might discover 'mooi klippen' (pretty stones), and in this way numbers of diamonds are said to have been found scattered over the 'veldt' (open country) for hundreds of square miles' area. It is stated that one of the best stones South Africa has produced was found at this time under these circumstances, and although its history is somewhat obscure, it is believed that a native picked it up in the 'veldt,' and that it was purchased from him in the first instance for a very small consideration. The site where this is reported to have been

found is more than a hundred miles distant from what have been considered hitherto as the diamond mines of South Africa.

The drift about the banks of the Vaal River was soon after found to contain diamonds, and digging and washing operations were carried on here for a short time very extensively, but with very varying results. Whilst some diggers undoubtedly were successful on the whole, the 'river diggings' did not pay well, and they have now been almost, if not altogether, abandoned.

Whilst the river diggings were in active operation, attention was still given to the occurrence of diamonds in the 'veldt,' until they were found comparatively so abundant in two or three places that the finders thought it might be worth while to search the soil for diamonds, and in this way the Diamond Mines were discovered. At first the soil was only turned over for a foot in depth, the workers thinking that the ground would not yield diamonds below that depth. It was found, however, afterwards that the diamantiferous material was not confined to a foot in depth, but extended to a considerable depth. Little or no water was available for washing purposes to the early diggers, and all the material was sorted dry, for what diamonds it might contain, and hence arose the term 'dry diggings,' which was given to these mines in contradistinction to the 'river diggings.'

The mines 'Du Toit's Pan,' 'Bultfontein,' and 'De Beer's'—all within a mile or two of each other—and 'Coffeefontein' and 'Jagersfontein'—in the vicinity of Fauresmith, in the Orange Free State—were found simultaneously or soon after each other; and lastly, the 'New Rush,' or what is now known as the celebrated Kimberley Mine, was opened upon.

Many other rushes occurred, consequent on the discovery of material, in different parts, that looked very much like that which contained diamonds in the mines previously worked, but most of them have not been found as yet to contain diamonds.

Soon after the diamond mines commenced to work, it was found that the area of the diamantiferous material was in each case limited by being surrounded by a barren rock, quite void of those gems. The point of junction with this and the diamantiferous material was very distinct, and the areas of the diamantiferous material in the mines Du Toit's Pan, Bultfontein, De Beer's, and Kimberley were discovered to be respectively about 30, 20, 15, and 9 acres. For working purposes each of these areas are divided into imaginary squares called claims, of 100 square yards each. At first diggers would acquire licences to work two or more claims, working one part for diamonds, and using the other for depositing the *débris* obtained from the claim or claims worked; until at length the non-worked portions began to fall, with their worthless *débris* on top of them, into the deeper claims which were being worked alongside of them. In this way one of the earliest mines—Du Toit's Pan—has been brought into a very disreputable state, for few diggers have capital to remove the worthless rubbish that falls into the workings in this way.

In starting the working of the 'New Rush,' or what is now the Kimberley Mine, precautions were taken to avoid the system of working that had brought such disaster to Du Toit's Pan, and roadways were preserved at intervals of 60 feet, parallel to each other across the mine; and for this purpose every claim was made subject to a reservation of 7 feet 6 inches. All claim-holders were compelled to make use of these roadways to carry their material outside the margin of the mine before depositing it. At length, however, through the constant removal of diamantiferous ground abutting on what was left standing to form these roadways, these also became dangerous, and unfit for working in, as well as dangerous as roadways for carting the stuff out of the mine. Numerous accidents followed on account of the diggers persisting in their operations, notwithstanding the danger. All manner of devices were adopted or proposed for preserving these roads, but in the end they all had to be abandoned; and the difficulty then arose as to how the claims in the interior of the mine should be provided with the means to discharge their diamantiferous material without molesting or interfering with their neighbours. And this difficulty was at length met by the principle of fixed wire tramways, which consisted of wire ropes fixed in the several claims and at the margin of the mine, and drawn up tightly by some mechanical appliance, such as a windlass or a screw. From these fixed wires buckets are suspended by a hook, which hook is fitted with a pair of wheels for running along the fixed wire, the buckets, when suspended, hanging vertically under these wheels, which are the points of support (*fig.* 2325). Windlasses, horse-gins, or small steam engines fixed on the margin of the mine, are used for winding these buckets along the fixed wire. On this principle far the greatest part of the diamantiferous material is now drawn out of the Kimberley Mine. In the first instance human labour was the only motive power used for winding in this way, but recently horse and steam machinery have been superseding it to a great extent, the capacity of

the buckets varying from about one cubic foot, for human labour, up to one cubic yard for steam machinery. For these heavier weights two lines of wire have been used for one bucket, having four wheels—two for each wire—and travelling along the two wires precisely similarly to the working of an ordinary tramway, except that the weight is suspended below the wheels.

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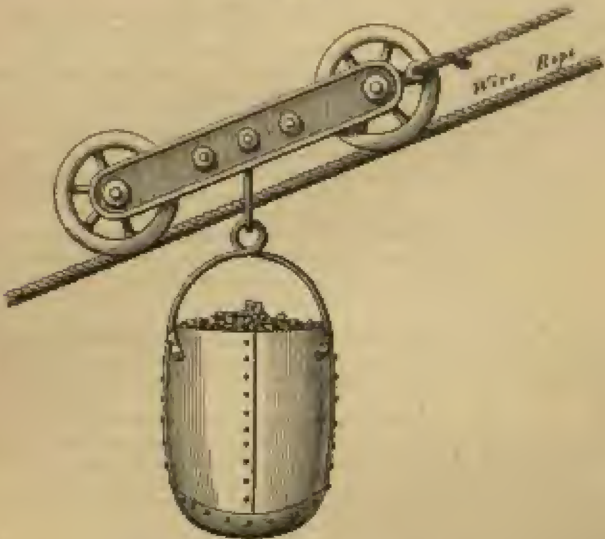


The number of miners employed in and for the Kimberley mine is not nearly as great now as it was in the early days of its working, but the number is still considerable. A rough estimate has been made, which gives 1,000 white men, 10,000 natives, and 1,000 horses, and about 60-horse power of small steam engines, as the total power employed.

At one time it is stated that there were no less than 1,000 individual interests in the mine of Kimberley, which is, as before stated, about 9 acres' area, each interest having its own windlass of the fashion described, and all winding from the margin of the mine. So many, indeed, were these, that the margin of the mine was not sufficient standing ground for all this winding apparatus, and staging had to be erected providing for tiers of two or three of these windlasses over each other. The appearance of the mines at this time, with such a large number of fixed wires all more or less converging from the circumference to the centre, was something similar to a huge spider's web, and, joined with the whizz and burr of such large numbers of windlasses in action, and the incessant shouting and yelling of the native workers, presented a very striking and singular scene to the eye of an observer.

Now (1876) the number of interests has been reduced to 300 or 400; this has tended to lessen the number of these separate winding appliances; but the depth to which these fixed wire tramways can be continued without having some intermediate support must necessarily be very limited, on account of the enormous strain which the ropes suffer when the load is on it and about midway between the points of support. This has been so far appreciated already that shafts are now being sunk outside the mine in the 'country,' or natural rock, and these are to communicate by drifts into the diamantiferous ground of which the mine consists, and along these drifts it is intended to convey the material from its original site to the bottom of the shafts through which it is to be hoisted.

The process of extracting the diamonds from the *débris* with which they are associated has varied. On the discovery of the mines the stuff was simply allowed to disintegrate through atmospheric influences, after which it was passed through a series of sieves of different sizes; that which passed through the finest sieve being treated as refuse, or such as not to contain diamonds of sufficient magnitude to be worth sorting; whilst the various other sizes were all sorted over on a table—which,

to say the least, was a very tedious operation. Diamonds in any case being seldom found, made the work, too, so monotonous that instances are known where very patient searchers have not noticed diamonds which must have passed under their eye, and the diamonds have in this way escaped the detection of the searcher. This process was known as the 'dry sorting process,' and the diggings the 'dry diggings,' both being used in contradistinction to the 'river diggings' and the process of washing for diamonds.

More recently—since the sinking of wells and the discovery of water in the mines themselves, as they have become deepened, have given the diggers a better supply of water—the washing process has been applied to the material of the so-called 'dry diggings,' as well as to the 'river diggings.' Different machines have been constructed for washing for diamonds, but the principle of obtaining the diamonds seems to depend on the fact of the greater specific gravity of the diamond than of the large quantity of calcareous matter with which it is associated, joined to the fact of the little cohesiveness that exists between the muddy water (which is considered on this account most suited for the purpose) and diamonds, compared with what exists between that medium and the particles of calcareous or shaly rock matter. The residuum from these washing processes consists chiefly of the minerals ilmenite, garnet, pyrites, &c., and particles of basaltic rock, all of which have as great, or greater, specific gravity than the diamond, and this residuum has to be sorted over carefully, as in the process of 'dry sorting,' for such diamonds as it may contain, excepting that the quantity to be so treated is perhaps only 5 per cent. of what would require to be so treated by the 'dry sorting process.' The washing process has proved a much more economical and safe process than the 'dry sorting,' insomuch that almost the whole of the material of the refuse from 'dry sorting' has been washed over for diamonds, and given very satisfactory results.

The comparative richness of the diamond mines varies; but it has been stated that approximately the gross mean value of a ton of the diamantiferous material from Kimberley Mine is about 25s., whilst that of De Beer's and Du Toit's Pan mines is probably less than half this, and that of Bultfontein less still. But this figure must only be considered approximate, for there is no direct evidence on the point, as no statistics of returns are kept, and the money value will necessarily vary with the market price of diamonds, that stated having reference to what it was in the early part of 1876. The diamantiferous ground varies very much in productiveness even in the same mine. For instance, in the Kimberley Mine, which is now (1876) assessed for rating purposes at a gross value of about 1,000,000*l.*, the sum per claim varies from 5,000*l.* to 100*l.*, and although the mean value per claim of the Kimberley is greater than that of the other mines, still there are many claims in the Kimberley Mine which are scarcely considered worth working, whilst there are a few in the poorer mines of De Beer's and Du Toit's Pan which are considered valuable, and realise considerable sums when they change hands.

On account of the Kimberley being the richest of the mines, it has received by far the largest share of attention, and from it by far the best results have been obtained. The area of the mine is, as before stated, about 9 acres; its shape in plan is somewhat elliptical, being 300 yards in length and 200 yards in breadth. The greatest depth attained in the beginning of 1876 was about 170 feet, and mean depth probably not more than 100 feet—the richest points of the mine, as might be expected, having received most notice and been worked to the greatest depth. Some small quantity of water finds its way into the mine, but as yet this has not been a very formidable difficulty, a small steam-engine of about 10-horse power being amply sufficient for removing it. By far the greatest difficulty which the diggers meet with is the constant source of danger and expense arising from the tendency which the sides of the mine have to fall down into the mine, and upon the ground where the diggers are engaged. This requires, therefore, considerable attention to avoid accidents, and expense for removing the broken parts, as they from time to time occur.

It is estimated that the year 1876 will require an expenditure of nearly 100,000*l.* for this purpose, and there is every reason to assume that the quantity of material of this kind which must be removed will increase in the ratio of the square of the depth attained, which may be said now to be about 100 feet, and is being increased at the rate of about 20 feet per year.

The Kimberley Mine presents in one view, perhaps, one of the greatest monuments of human industry, as applied to mining, as can be seen in the world, for whilst many mines are, in their several subterranean workings, much more elaborate and extensive, yet the whole extent of these cannot be seen at once, as can that of the Kimberley Mine, which is entirely exposed to daylight. Notwithstanding the notoriety of the Kimberley, it can scarcely be considered a credit to the times. Most of the work which has been done at an enormous cost by human labour might have been effected

with much better economy by machine labour, and a combination of the present individual interests would have reduced several of the charges of the mine to a minimum, instead of maintaining it at the maximum which is now forced through the very great subdivision of interests. Still, its working has been attended with extraordinary results. It is estimated from the time of its discovery till the end of 1875 (about five years), not less than 10,000,000*l.* of diamonds have been obtained from it. The cost of maintenance of the working of the Kimberley Mine, with the staff engaged at present, is, perhaps, about 1,000,000*l.* per annum.

Respecting the geological features of the diamond mines, they are very singular, but at the same time those of each of the mines seem to be very much in common with the others. What are known as the 'river diggings' are comparatively simple enough, and consist of a 'boulder drift' in the bed, and on the banks of the river Vaal; but the 'dry diggings,' generally speaking, consist of pipes or chimneys of diamantiferous material cropping up in various parts of the country, the areas of which respectively are more or less defined, and vary considerably in extent. The walls of the containing rock about these pipes, as far as has been ascertained, are more or less vertical, and consist in most instances of shale broken by numerous 'faults' and intrusions of basalt; whilst the diamantiferous material is a 'breccia' of fragments of limestone, shale, and basaltic rocks, with a sprinkling of pyrites, garnets, mica, spinelle, ilmenite, &c., with occasional diamonds, and other minerals, all cemented together by a calcareous clay. Instances have been known of the occurrence of specimens of charred wood, and some of the fragments of limestone contain fossils.

The four principal mines are Kimberley, De Beer's, Du Toit's Pan, and Bultfontein, and are all contained within a circle described by a two-mile radius, and it is singular that, although the containing rock in each mine is more or less distinctly defined about the diamantiferous ground, in each of the mines there remains a point where it is not so. The diamantiferous material has only been followed by the 'diggers' as far as they have considered it remunerative, and where it has become not so, they have discontinued their operations, and there is therefore no evidence to show that the diamantiferous ground in all of the mines are not part and parcel of the same, connected with each other by more or less fine seams of the same material. It is possible that this is the case even at the surface, but whether this is so or not, there are strong grounds for presuming that these 'breccias' of diamantiferous material are an eruptive formation, and that the whole of the so-called separate 'deposits' or 'mines' communicate with each other at some indefinite depth.

The mines Jagersfontein and Coffeefontein are in the territory of the Orange Free State, and are distant about 80 miles south of those of Griqualand West. The mode of occurrence of diamonds, and the formation generally, as far as can be seen, are precisely similar to those of Griqualand West; but they are generally considered to be much poorer, and on that account are being very little worked.

Numerous discoveries have been made in the neighbourhood of the diamond mines from time to time of other deposits, which at first sight present no material difference from those of the diamond mines. In each instance these discoveries caused very considerable excitement, but in no case have they been found to contain diamonds in sufficient quantities to cause their being worked. Indeed, considering the inducements which exist at such times for fraud, it is doubtful whether the diamonds which have been reported to have been found in these discoveries were actually found.

There seems now no reason to assume that the deposits of material containing diamonds in the mines of Griqualand West will discontinue as greater depth is attained, but rather to presume that they will extend to such depth, as will render the cost of working so great, as to enforce a much more economical system of working than the present large number of individual interests will admit of.—F. O.

Diamonds, Australian.—'As early as 1860, the Rev. W. B. Clarke mentions the discovery of diamonds in the Macquarie River, but gives no information as to whether they were found in the present river bed, or in an ancient river drift. The Mudgee diamond works are situated about 170 miles south of Bingera, on the Cudgegong River, which runs into the Macquarie River, and that again into the Darling River. The gold-diggers first discovered diamonds here in 1867; they were neglected until 1869, when they were rather extensively worked. The localities lie along the river in the form of outliers of an old river drift at varying distances from the river, and at heights of 40 feet or so above it. These outliers are capped by deposits of basalt, hard and compact, and in some cases columnar. This basalt is regarded by Mr. Taylor as of Post Pleiocene age, but this has not been determined directly by any fossil evidence. There are five patches of this ground being worked, in all comprising about 510 acres. In one of these patches a peculiar deposit of crystalline cinnabar was found. No diamonds have been found in the river bed,

except in places where the diggers have discharged the drift into the river when washing for gold.

'Amongst the minerals associated with the diamonds are the following:—1. Black vesicular pleonast. 2. Topaz. 3. Quartz. 4. Corundum, *a.* Sapphire; *b.* Adamantine spar; *c.* Barklyite; *d.* A bluish-white variety characteristic of Mudgee; *e.* Ruby; *f.* Rolled corundum, dirty-white and pink. 5. Zircon. 6. Tourmaline. 7. Black titaniferous sand. 8. Black magnetic iron-sand. 9. Brookite. 10. Wood-tin, rare. 11. Garnets. 12. Iron from tools. 13. Gold. 14. The Diamond.

'The largest diamond found here was 5⅛ carats = roughly 16·2 grains. The average sp. gr. 3·44, and the average weight 0·23 carat, or nearly 1 carat grain each. The carat contains 4 carat-grains, which are equal to 3·16 grains troy. The Newer Pleiocene drift afforded a few diamonds. Diamonds have also been found in Victoria, but of small size and in no large quantities.

'The Bingera Diamond Works are situated in a basin or closed valley amidst the hills; this basin is about four miles long by three wide, and is open to the north. The rock upon which the diamond drift rests, or the "bed rock" of the minerals, is an argillaceous shale. In one part of the field a junction of the argillaceous shale with conglomerate is clearly shown in a cutting formed by a small gully. Both the shale and conglomerate beds appear to have undergone much disturbance, and at this particular spot diamonds are said to be plentiful on the conglomerate but not on the shale. Up to the present all the diamonds have been found within a foot or so of the surface, in fact just at the grass roots. In no case have the workings been carried to greater depths than two or three feet. In former sinkings the gold digger occasionally found diamonds at the depth of 60 feet or more, but as the men were working for gold, little heed was paid to the diamonds, and it is probable that they fell in from the surface.

'The list of minerals accompanying the diamonds in the Bingera Works is as follows:—1. Tourmaline. 2. Zircon. 3. Sapphire. 4. Topaz. 5. Garnet. 6. Spinelle. 7. Quartz. 8. Brookite, rare. 9. Titaniferous iron. 10. Magnetic iron ore. 11. Wood-tin, rare. 12. Gold. 13. Osmiridium. 14. Diamond.

'One of the Companies, when prospecting the ground, found the drift to yield as follows:—

6	loads yielded	41 diamonds
4½	"	143 "
6	"	86 "
6	"	125 "
6	"	163 "
6	"	89 "
	Refuse from machines, &c.	41 "
34½		690 "

or on the average 23 diamonds per ton of stuff, regarding the load as equal to 1 ton. The above were obtained by the Gwydir Diamond Mining Company.

'The following is an account of the number obtained by Messrs. Westcott and M'Caw from the Eaglehawk claim, up to August 26, 1873:—

406 diamonds	weighing	192 grains
420 "	"	199 "
310 "	"	153 "
200 "	"	109 "
350 "	"	150 "
1,686		803 " troy

'Up to the present no large diamonds have been found, the largest hitherto met with being 1 only of 8 grains, 1 of 4 grains, 6 of 3 grains, 25 of 2 grains, and 1,557 of less than 2 grains.

'No mention is made of the kind of drift from which the above quantities were obtained; they, however, afford an opportunity of roughly estimating the yield.'—*Professor* Liversidge, *of the University of Sydney.*

The following account of the discovery of diamonds in New South Wales is from the pen of the Government geologist in the *Mines and Mineral Statistics of New South Wales*, published in 1875.

'On the Borah Creek, which flows into the Gwydir about two miles above the junction of the river with Cope's Creek, several patches of pebble-drift, iron-stone, and clays capped with basalt, mark the course of a small lead. Not far from its

source the Borah Creek crosses the lead, and for about $2\frac{1}{2}$ miles down the valley, which lies between abrupt granite ranges, it has been entirely denuded, but below this point it may be traced now and again in a N.E. direction by patches of drift covered with basalt. It is immediately below where the creek has first cut through the lead that the operations of the BORAH TIN AND DIAMOND MINING COMPANY have been carried on in sluicing the more recent alluvial drift. Beside several tons of stream tin, upwards of 200 diamonds were obtained in a few months. Mr. THOS. ADAMS, one of the proprietors, showed 86 of the diamonds, which were weighed and found to average 1 carat-grain each, the largest of them weighing 5·5 carat-grains. They are mostly of a light-straw and pale-greenish colour. Several were nearly octahedral crystals, but the rest were modifications, with curved facets and edges, some appearing almost spherical in shape. Sapphires and garnets occur in the diamond-bearing drift, together with small polished black pebbles. If the diamonds have been derived from the old lead, no doubt many more will be found where it has been entirely denuded, and the tin ore and diamonds it contained have been re-distributed in the alluvial deposits lower down the creek. From the Bengonover Mine, about two miles below the Borah Mine, several diamonds were examined: the largest, not of good form, weighed 7·5 carat-grains, and gave specific gravity 3·4.

'The fact that the diamonds from the Borah Mine are found in the creek, immediately below where it has cut through the lead and the small black pebbles associated with the diamonds, may point to the former existence of another formation, but no vestige of it *in situ* now remains to prove it. The surrounding country appears to be entirely of granite. Whether the lead may be the original matrix of the diamonds, is a question difficult to determine; it may, however, be mentioned that the facets and edges of the diamond crystals do not appear to be in the least degree water-worn or abraded. It is said that two diamonds have been found near Newstead. Another one was obtained with the tin-ore from the old tertiary drift at the Stannifer Tin Mine, Middle Creek, and three others have been discovered in Darby's Branch Creek at the Britannia Tin Mine.'

The first mention made of the existence of the diamond in New South Wales is one by Mr. E. H. HARGRAVES, who, in his report, dated from the Wellington Inn, Guyong, on July 2, 1851, refers to some enclosed specimens of gold, gems, and 'a small one of the diamond kind,' from Reedy Creek, 16 miles from Bathurst. The next record of the occurrence of the diamond in New South Wales appears to have been made by the Rev. W. B. CLARKE, in an appendix to his *Southern Gold Fields*, published in 1860; he records that four were brought to him on September 21, 1859, which were obtained from the Macquarie River, near Suttor's Bar; the crystalline form which they exhibited was that of the triakisoctahedron, or three-faced octahedron, and one of them had a sp. gr. of 3·43. Another, which was received from Burrendong, on December 29, 1859, had a sp. gr. of 3·50. One from Pyramul Creek, crystallised in the hexakis or six-faced octahedron, weighed 9·44 grains, and had a sp. gr. of 3·49. Another was sent to him in August 1860, which had been found in the Calabash Creek by a digger as far back as 1852.

Diamonds were found by the gold diggers on the Mudgee Diamond Diggings in 1867, but were not especially worked until 1869.

The diamonds were obtained from outliers of an old river-drift, which had in parts been protected from denudation by a capping of hard compact basalt. This drift was made up mostly of boulders and pebbles of quartz, jasper, agate, quartzite, flinty slate, silicified wood, shale, sandstone, and abundance of coarse sand mixed with more or less clay.

Many of the boulders are remarkable for the peculiar brilliant polish which they possess. The principal minerals found with the diamond are gold, garnets, wood-tin, Brookite, magnetite, ilmenite, tourmaline, zircon, sapphire, ruby, adamantine spar, Barklyite, common, and a peculiar lavender-coloured variety of, corundum.

The lustre is usually brilliant or adamantine, but occasionally they have a dull appearance.

The diamonds at Bingera occur under almost exactly the same circumstances as at Mudgee, and with the same minerals.

From a series of determinations made of nineteen of the Bingera diamonds, a mean sp. gr. of 3·42 was obtained. (For details *vide* paper upon the Bingera Diamond Fields, *Trans. Roy. Soc., N.S.W.*, 1873.)

Diamonds have also been found at Bald Hill, Hill End, with the same gems as at the above-mentioned places; one octahedral crystal, rather flattened, weighed 9·6 grains (troy) and had a sp. gr. of 3·58.

A specimen of 'bort' or black diamond was obtained near Bathurst; it is of about the size of a large pea, black in colour, with a graphitic or black-lead lustre: it is very nearly spherical in form, but has a few slight irregular processes, which seem to

be due to an attempt to assume the form of the hexakis octahedron. Its weight is 7·352 grains troy.

Mr. Wilkinson mentions that from the Bengonover Tin mine several diamonds were obtained, the largest weighing 7·5 grains. Two hundred diamonds were obtained in a few months at the Borah Tin Mine. Diamonds have also been found in the Turon, the Abercrombie, the Cudgegong, Macquarie and Shoalhaven Rivers. One was found in August 1874, valued at 3*l.*, in Brook's Creek. There are several other localities in which small diamonds have been found.—For these consult Professor ARCHIBALD LIVERSIDGE's *Minerals of New South Wales.*

DIAMONDS, BLACK.—The Société d'Encouragement pour l'Industrie Nationale of Paris are offering (1877) a prize of 3,000 francs for the artificial preparation of compact black diamond (commonly called bort or carbonate), and for obtaining thereby a powerful means of action for working hard metal substances, &c. We know that the carbon deposited on one of the poles of a voltaic circuit is so intensely hard that it is used for polishing diamonds.

Among the comparatively recent mechanical arrangements are many in which the diamond is made to play an important part. Diamond drills have proved valuable for prospecting mines. Again, the diamond is now also being used in this country and in America for channelling and quarrying stone, as well as working and carving it by rotary and traversing drills or bits of various sizes and shapes, armed on their surface with black diamonds which are shaped with sharp angular or curved cutting edges; these bits are made to traverse and rotate at a very high rate of speed, following the interior line of a templet, producing thereby beautiful patterns of panelling of any design or depth desired in stone. The rapidity with which the work is done, and the smoothness of finish, is something marvellous. These points are also used effectively for tracing hardened steel faces, such as dies, &c., also chilled iron and paper calender rolls.

Much credit is due to M. Leschot, of Switzerland, for bringing into extended use the black diamond for tunnelling, &c. The black diamond, which is found to be the cheapest, hardest, and most durable of the diamond species, was discovered among the diamond mines of Brazil. It is found generally in pieces about the size of a pea, and sometimes in masses of over 1,000 carats. It is opaque, and in outward appearance resembles iron ore, while it is often covered with a bright black skin. When broken the interior is all of one colour, grey, and presents the appearance of a compact crystalline substance like that of fractured steel. Its use for the purposes previously mentioned, as well as for working the transparent gem for ornamentation, proves it to be the hardest known substance, which gives it the precedence and preference to steel where durability of a cutting edge and accuracy are required.

The inventor or discoverer of the means or process for reducing this densely hard and valuable mineral is an American, a worker of diamonds in their natural state most of his life, and who has made their character and nature a study. Being alive to the prospective extended field of usefulness to which the diamond might be applied, he visited some few years back the diamond workers of Holland and other European countries to ascertain if it had ever been or could be shaped. The universal reply was, these black diamonds neither had been nor could be shaped, they were so hard no lap would grind them to an acute angle, like steel; while even if they could be shaped by the same means employed with diamonds, the very cost of doing so would prevent their profitable use as a substitute for steel. Nothing daunted, and regardless of such discouraging information from some of the oldest and most experienced shapers and grinders, he returned home with the set determination to solve the problem, and, if possible, obtain the desired results. After many experiments he realised his most sanguine hopes, and succeeded in reducing the black diamond into any shape desired, with acute edges, as with steel, and at such cost as to make them practically useful for working stone as well as hardened steel.

DIAMOND WASHING MACHINE. Mr. ATKINS, of Kimberley, constructed a machine for washing diamonds and sought a patent for it. This was submitted to an engineer, and from his report the following abstract is made:—

'There can be no doubt but that there is a certain similarity in the mechanical construction of Mr. ATKINS's machine for which a patent is sought, and some others which are used for entirely different purposes—such as those used for disintegrating clays—either for the purpose of removing gritty matter from the clays and economising the clay, or else for getting rid of the clay matter and economising the sand or gritty material, in the former of which may be considered a machine which is used for making mortar and brick material, all the rough or grit material which it is desirous of getting rid of being deposited in the circular or annular trough, whilst the clay-matter remaining in suspension in the slightly agitated water flows over

with it, and is collected as a sediment in suitable receptacles provided for that purpose. In the latter case, where the sand and grit material is sought for, we may consider what is known in gold-washing countries as a "puddling machine," where the lumps of alluvial clayey matter are placed in the machine. After disintegrating them, it allows the clayey matter to pass over (with the water) the upper ridge of the trough, whilst the grit and sand material is left in a state more fit to be subsequently treated for its metallic contents.

'Notwithstanding the similarity in construction between Mr. Atkins's machine and those referred to, there is such an alteration in the relative proportion of parts as to make it quite unfit for disintegrating the alluvial clays for which the "puddling machine" is peculiarly adapted, and also unfit for the separation of gritty stuff from mortar-like material. Mr. Atkins's machine is neither a "puddling machine" nor a "mortar-material machine;" neither of these will answer the purpose of diamond-washing, which this machine is especially adapted for.

'There is quite another principle involved in obtaining diamonds by Mr. Atkins's machine from that which is brought into action by merely disintegrating clays and removing the grit from them by the other machines. The principle to be explained as accounting for the deposition of diamonds in Mr. Atkins's machine involves the consideration of a rather abstract scientific subject. Any material heavier than water, if let fall into water, descends with a velocity proportionate to the specific gravity of the body, and the amount of its superficial area as compared with its bulk, the latter of which diminishes in the proportion of the square to the cube of its mean diameter.

'In illustration of this, like bulks of similar specific gravity and equal surfaces descend with equal velocities; unlike bulks with similar specific gravities, with unequal velocities; and further, it is quite deducible from this law that even a body with the lesser specific gravity may have the greatest velocity in descending through water, provided that the body with the least specific gravity has also such small amount of surface, when compared with that which has the greater specific gravity, as to account for the greater velocity of the former. For instance, a sheet of gold might easily be suspended in water which is sufficiently agitated, where a sphere of iron would sink readily, although the former is nearly three times the specific gravity of the latter.

'On the law just explained depends the action of the mortar-material machines and the puddling machines, for although the particles of clay or fine matter might happen to be of greater specific gravity than the particles of grit which descend, yet the former remains suspended in water, and is carried over along with it, owing to the greater amount of surface of the clay particles compared with their bulk than what exists in the particles of grit matter or sand. But in Mr. Atkins's machine, very small diamonds are left in the trough, whilst comparatively large pieces of gravel are thrown out; the specific gravity of this gravel or waste matter which is discharged compared with the diamond is only in the ratio of 2·5 to 3·5–6, which is not sufficient to account for the retention of such small diamonds and the discharge of such large pieces of waste matter as the machine is capable of. This fact is in opposition to the law upon which the puddling machine and mortar-material machine acts, as these are found to throw out their clays and to retain their coarse material. I can only account for this action of this machine by its peculiar construction and proportion of parts, producing some other action than that of the others, whilst the latter (puddling machine, &c.) have such a reservoir of water as to allow of the subsidence of the coarser material and the outflow of the water with the clayey matter.

'The diamond material is taken into this machine in a dense liquid state of slime and water. The force of cohesion between the waste particles and the slime water is greater than that existing between the diamonds and slime water, thus admitting of the more ready suspension of the former when compared with the latter, and in this way the diamonds more readily sink through the slime water to the bottom of the trough. Also, while the diamonds may be actually in suspension, they are not so readily carried by the rakes to the exit part of the trough (owing to the greater smoothness not only of the faces of crystals, but also in the case of splints from their excellent cleavage planes) as the rougher particles of waste.

'This principle of dressing diamonds is exemplified in the deposition of the diamonds in the annular trough with minerals of much greater specific gravity, and apparently in common with each other, such as iron pyrites, ilmenite, and garnet, whose specific gravities are 4·9–5·1, 5–6, and 3·1–4·3 respectively, whilst the diamond has only a specific gravity of 3·5–6.

'This fact of the little cohesion existing between the diamond and the slime water, combined with the smoothness of the diamond faces, accounts for the violation of the law before explained, and further is appropriated by Mr. Atkins's machine with approximate completeness.

'It is therefore due to the changes in proportion of parts between the "Protected Machine" and the others, that the former is made to answer for the purposes of diamond-washing.'—F. O.

DIDYMIUM. (Vol. ii. p. 20.) This metal has been detected in pyromorphite from Cumberland.

To separate didymium from lanthanum the solution containing the two metals is precipitated, to the extent of one-half, with ammonia, and the washed precipitate is left for twenty-four hours at the ordinary temperature in contact with the rest of the solution, being frequently stirred. The lanthanum, being the stronger base, then passes into the solution in predominant quantity. The lanthanum solution thus obtained is treated in the same manner. After the second treatment the solution gives but slight indications of the presence of didymium, even with the spectroscope.

Erk considers a didymium solution as free from lanthanum when, on precipitating the oxide with ammonia and treating it as above, no difference of colour or of atomic weight can be found between the filtrate and the oxide precipitated from the filtrate.—*Erk, Zeitschr. für Chem.* (2), vii. p. 100. For equivalent and atomic weight, see *Watts's Dictionary of Chemistry*.

DIHYDRITE. A phosphate of copper, having the composition $Cu^3P^2O^8 + 2Cu H^2O^2$, or $3CuO . P^2O^5 + 2(CuOH^2O)$.

DIPHENYLAMINE. Diphenylamine yields a remarkably fine blue colour with concentrated nitric acid on methyl-diphenylamine, which is obtained by treating diphenylamine by iodide of methyl at temperatures above 100° C. It yields blue or violet compounds with arsenic acid and with the metallic nitrates, chlorides, iodides, or bromides. See Aniline, Electrolysis of.

DIPICRYLAMIN. See Aurantia.

DISTRIBUTING MACHINES, TYPE. See Printing.

DIVING AND MINING APPARATUS. See Diving Bell and Diving Dress, vol. ii. pp. 61, 65.

The use of the diving dress has been long known, but it is only of late years that attention has been directed to the use of dresses of a similar description to enable men to enter into the atmospheres of mines charged with the effects of the explosion of fire-damp, or to penetrate the suffocating atmosphere of rooms during a fire. All the arrangements which have been introduced consist of a dress perfectly air-tight, fitted with valves and tubes, by means of which pure air is supplied to the wearer, and all the products of combustion are rapidly carried off.

The Aërophore of Denayrouze has attracted much attention, and his application of the submarine lamp in connection with it merits careful consideration.

The diving dress is composed of an elastic waterproof covering, in a single piece, enclosing the whole of the body and limbs, leaving the extremities free, excluding water at the wrists, and provided with strengthening pieces at all points where experience has shown that there is a tendency to wear. It is fitted around the neck, over the shoulders, with a flat indiarubber collar having three lugs or ears, perforated for the fastening to, and connection with, the helmet. This latter is constructed in two parts united by flanges, and screw-bolts and nuts, whereby the indiarubber collar of the dress is tightly compressed, so as to make a perfectly watertight joint and connection; the upper part is the helmet proper, covering the head, and the lower part is the gorget or breast-plate, which rests upon the shoulders; the collar, being turned over the flange of the gorget, acts as a washer when the helmet-flange is placed on it and tightened up by the bolts and nuts. The headpiece is provided with four glazed openings, and fitted with two air-outlets, whereof the one is an external tap, which the diver can open and close with his hand, the other being a spring-valve with an internal spindle and knob, opening thus with the merest pressure of the head, at the diver's will.

But the most important part of the apparatus relates to the supply of air, which, by a simple and natural device, is kept cool and pure, notwithstanding that the pump may be worked in a place where the air is liable to be vitiated, as in a well, or coal-mine. Moreover, inasmuch as practical experience in diving operations has shown that the direct supply of air from the pump is attended by considerable inconvenience and some risk, a great improvement has been effected by the interposition of an air-reservoir, so that the diver is supplied from a stored volume of air, in lieu of directly from the pump, relieving him from excessive pressure, regulating the supply, retaining the air by a valve, distributing it as required, and continuing the supply for some time, even should the pump from any cause have ceased to work.

The pump is double-acting, and constructed on the oscillating lever principle; the pistons being fixed and pivoted to the bed-plate, and the cylinders similarly attached to the operating lever being thus made moveable. The plunger-pistons, fixed vertically, are leather-packed to prevent escape, and have water-joints, being covered with

a certain depth and volume of water; and thus the air is kept cool and pure by being forced through two layers of water. Similarly, the air-reservoir being also partially filled with water, the air, before reaching the diver, is passed through water three times, whereby one of the greatest obstacles and objections to the employment of compressed air is obviated and overcome.

The accessories comprise air-pipes or tubes, weights affixed to the helmet, carried on the back and chest, and lead-soled shoes, whereby the diver is enabled to move and stoop freely at the bottom of the water. The air-connections are india-rubber tubes, constructed on a special system, with wire coiled spirally in the interior, so as to be capable of resisting great pressure, such as would be exerted at a depth of 500 feet, *i.e.* 15 atmospheres or 2 cwt. per square inch. Nevertheless, the specific gravity of the tubes is less than that of water, so that they are light enough to float vertically above the diver, and thus to avoid entanglement.

The speaking apparatus is simply composed of a separate india-rubber tube, fitted at its upper end with a trumpet mouthpiece, and terminating below in a union-joint screwed on to an economised chamber in the helmet, which serves as a sound-box.

Although such a diving apparatus may be supposed to have had, for its primary object and application, strictly submarine works, yet its use and advantage in subaqueous works in mines could not long escape notice. Accordingly, it is adopted by the principal naval administrations, and the authorities concerned in submarine hydraulic works, fisheries of sponge, pearl, nacre, amber, and the like; but also for mines, in the repairs and maintenance of pumping apparatus, and the more especially since the invention by DENAYROUZE of a subaqueous lamp.

As a speciality for mining, the Aërophore has equal claims to note in connection with the difficulties of ventilating mines, and the avoidance or minimising of risk after an explosion, and it embraces the advantages of the possibility of supporting existence in a vitiated atmosphere. In cases of deficient and imperfect ventilation, or from the sudden disruption and fall of the stratified material, all mines are liable to the generation and accumulation of carburetted hydrogen, leading to interruption of the work. These evils may mostly be avoided by employing the DENAYROUZE apparatus, and it forms an effectual means for enabling the miners to penetrate the midst of an inflammable or irrespirable atmosphere. The Aërophore supplies fresh air, and the DENAYROUZE lamp ample light, amid the worst gases; and in case of accident by explosion, it affords the means necessary for aid and rescue. Thus a miner is enabled to penetrate at once, and to a considerable distance, into workings filled with choke-damp, to carry his lamp with him, and to remain and have his arms free to work for several hours without danger.

The miner wears a pair of lunettes, with an india-rubber cushion protecting the eyes and nose from the noxious elements; and an india-rubber mouth-piece, kept continually supplied with fresh air for inhalation, and fitted with a valve for exhalation; this apparatus is so firmly attached and held that it cannot by any possibility become displaced, and thus the lungs are effectually protected.

The apparatus is made in two forms, low and high pressure. The former comprises an air-pump, a strainer, an air-tube wound on a self-regulating coil, and a regulator; the latter differing therefrom only in the kind of air-pump used, and in being provided with a set of high-pressure tanks or cylinders as reservoirs for the highly-compressed air. Thus, in the one case the air is stored, and in the other supplied directly, for the miner's use.

The low-pressure air-pump is constructed as for the purposes of diving and subaqueous work; the cylinders are moveable, the vertical pistons fixed, and covered with water as well as the delivery valve, so that the air is cooled and purified by its passage through two layers of water.

It will be understood that the same air which supplies the necessities of life to the miner is available for maintaining the combustion in the lamp, which is connected by a tube with the dress of the miner. In the collieries and mines of France, Belgium, and Germany, the DENAYROUZE dress and lamp has been much employed, and with many advantages.

DOLERITE. (Vol. ii. p. 69.) MOHL has analysed the dolerite and tachylite of Sababurg, in Hesse. These two minerals have very nearly the same composition.—*Jahrbuch f. Mineralogie.*

DOLOMITIC LIMESTONE CEMENT. EICHHORN has shown that a cement may be prepared from dolomitic limestone, which hardens under water more quickly than ordinary cement.

He finds, however, that though dolomitic cement hardens sooner, it never attains to the same degree of hardness as the ordinary cement. The dolomitic cement is compact and very useful for many purposes.

The hardness of cement increases as the proportion of water is diminished, until a certain minimum is reached, the minimum varying with each sample. The hardness also depends upon the proportion between the lime and the acid constituents of the cement. In the best cements this proportion averages 1 : 1·79.—Durand, *Poly. Jour.* ccxl., ccxiv.

DRESSING OF ORES. (Vol. ii. p. 72.) The author of the article on the Dressing of Ores in the Second Volume, and who has furnished a considerable quantity of matter for a supplementary article, being in South America inspecting some mining districts, it is thought desirable to await his return to England, to ensure the advantages of his corrections. See Ores, Dressing of.

DRILL, DIAMOND. (See Boring, vol. i. p. 442.) The Pennsylvanian Diamond Drill Company exhibited at the Centennial Exhibition an arrangement which is more compact than Beaumont's drill. There is very little difference in the form of boring crown employed; the core is lifted by a shell or thimble of the same size and shape as a core bit, and indeed may be combined with the same, being simply a recess in the inside of the thimble, composing the bit or core lifter, about 1 in. in width, bevelling inward and downward, toward, and coming within about 1½ in. of the face or lower end of the bit or core-lifter. In this recess is placed, loosely, a tempered open steel spring, about ⅛ in. wide, with three, five, or more vertical ribs to give the proper thickness, which may be armed on the inside with diamonds, to keep it from being worn by the core, and which, when the drill is descending, is pushed by the core up into the deep part of the recess, where it has no effect; but when ascending, slides down on the bevelled sides of the recess, which contracts it firmly against the core, which it carries with it to the surface. The drill is rotated by one of J. R. Root's 'square' engines, and the feed is regulated by two hydraulic rams placed on each side of the rods, connected to a crosshead. The crown is attached to the end of a wrought-iron tube from 8 ft. to 12 ft. long, the size of the hole intended to be bored, set with diamonds at intervals, to prevent it from wearing, and provided its full length with spiral grooves, to allow egress for the water and sediment on the way up to the top of the bore hole. The tubular boring rods are attached by means of a derrick above the machine as the depth of the hole increases, the flexible water tube being attached to the top of each rod as it is fixed. This enables the base of the machine to be fixed close to the ground, giving it great stability. The largest hole yet bored with this machine has a diameter of 9 in. and a depth of 357 ft. The deepest hole is 1,000 ft. from the surface. A new form of diamond quarry drill was shown by the same company, provided with a new friction feed motion and driven by one of Underwood's rotary engines. See Black Diamonds, p. 319.

DRILL, ROCK, and **AIR-COMPRESSOR.** The following is an abstract of a paper read before the Iron and Steel Institute on the Ferroux Drill by Mr. W. H. Penrose:—

'The works at the St. Gothard tunnel were commenced at the beginning of June, 1872, and continued till the following November at Goëschenen, and at Airolo, the preliminary cutting, leading up to the heading, was begun on July 1, and completed on August 24 following.

'The material encountered at the Goëschenen end was chiefly hard granite gneiss, at first full of fissures and cracks, but afterwards it was more homogeneous. The two tunnels at Mont Cenis and St. Gothard are not only remarkable as triumphs of engineering science in themselves, but they are also distinguished above all other similar works from the stimulus which their construction gave to the improvement and development of rock-drilling machinery, a branch of mechanism that deserved much more attention than it had received previously, for such labour-saving machines must ever be of great value in countries possessing any share of mineral wealth. The Mont Cenis tunnel formed the greatest trial-ground ever brought to the attention of inventors and makers of either rock-drills or air-compressors, and now St. Gothard is testing and condensing the experience gained at its older companion. It may fairly be said that at both tunnels every known example of rock-drill has been tried, the principal and most successful being the "Ferroux," the McKean, the Sommeiller, and the Dubois-François. Taking first, then, the Ferroux rock-drill, it is, as its name implies, the invention of M. Ferroux, formerly chief of the workshops for repairing the machines used at the Mont Cenis tunnel. To make the working of this machine clear, it is as well to say a word or two about rock-drills in general. Most of these machines consist of a cylinder and piston mounted on a supporting frame, and fitted with a screw to feed the boring tool up to its work, the screw being actuated either by the machine itself, or by an attendant. The piston and boring tool, when at work, reciprocate rapidly, and have also an intermittent rotative motion as well.

'The weak point in all such machines is the feeding arrangement; the nature of

the rock against which the machine operates is variable, and thus, at one place, the boring tool progresses more rapidly than at another; under such circumstances the feed should be exactly proportionate to the rate of progress. This can never be the case with a hand-fed machine, simply because the most careful attendant cannot tell whether the tool is in soft or hard stuff. The same argument applies to the ordinary automatically-fed machines in a still greater degree, because, be the rate of progress of the tool an inch per hour or a foot per ditto, the feed is uniform, and, if set for hard material, time and power are wasted in soft strata, while, on the other hand, if set for soft work, and a hard vein is met, then we have the tool jammed, and often broken; it will be evident, however, that the FERROUX machine overcomes this difficulty effectually.

'The feed in the machine is on the allotment principle, thus:—A certain piece of work is fed to the borer at once, and until this is perforated no more is given; if the borer perform the work in ten minutes, at the end thereof it gets another allotment; while if a hard vein is met with, taking say an hour to pierce, the borer will get no more till this be done, thus neither under nor over feeding can take place.

'The propelling arrangement is perfectly separate and distinct from the boring machinery in its action, and so neither over nor under feeding can possibly take place. The principal machine being designed only for tunnelling, it is too large for general work in this country, where but little tunnel work remains to be done. The machine measures about 10 feet long when shut up, by 1 foot wide and 1 foot 2 inches deep. The stroke is 6½ inches long, and the travel of the propelling piston is 2½ feet. The weight of the machine without the carriage is about 5 cwt.

'A much smaller and lighter machine is made for mines, quarries, and shaft-sinking, &c., where portable machines are requisite and space is contracted. The principle of this is the same as for the other machine, but the propelling cylinder is placed immediately beneath the borer; the total closed length of this machine is but 5 feet, and the weight 300 lb., and Messrs. ROY are improving even on this machine. There is no doubt whatever that this machine, or modifications of it, will exercise a great influence on coal-mining, and go far to supply the want of the age, viz., a good, efficient coal-cutting machine.

'*The Air-compressor.*—Messrs. R. ROY AND CO., the present owners of the FERROUX patents, are the original designers of the air-compressor for the works at Mont St. Gothard; they are on the high-speed principle, because the pressure of the air required at the St. Gothard rock is much higher than that needed at Mont Cenis. At St. Gothard a pressure of nine atmospheres is employed, and air compressed to this attains a temperature of about 500° Fahr. To meet this difficulty Messrs. ROY devised a method of circulating cold water through the interior of the piston, and not only this, but on its periphery as well, keeping the cylinder also cool. High-speed machines were essential, also, in order to economise space as much as possible.

'The description of one compressor will suffice, the quantity of air required being supplied by using a sufficient number of them. The diameter of the compressor cylinder is 0·420 metres, or about 16½ inches, the stroke being 0·650 metres, or about 27 inches, and thus each single stroke of the piston is equal to a volume of something more than three cubic feet. The pistons of the compressors are made as follows:—They are hollow, and the water circulation is maintained by a tubular rod, within which is a smaller tube. The tube reciprocates with the piston, and its extremity outside the cylinder is provided with a stuffing-box, which slides over the smaller tube, and through these the water is sent. The piston has four packing rings of brass placed in grooves on its periphery, and they are separated by a large groove in the centre of the periphery, which communicates with the hollow, water-filled interior of the piston by a hole bored for the purpose at the top. The water being maintained in the piston at a greater pressure than the air compressed in the cylinder, forms around the piston an effectual air-tight and lubricating ring, which also keeps the face of the cylinder cool. Moreover, a certain quantity finds its way into the cylinder by passing around the rings; it then mixes with the compressed air and cools it, while the work of compressing is going on, and so increases its effective power by preventing the heating and consequent dilatation of the air.

'The *Quarterly Report* of the Swiss Federal Council on the progress of the workings at the St. Gothard tunnel says:—

'In the heading works of Goëschenen, it was proved by observation made on a length of 6,352 metres of holes bored, that a FERROUX machine used for making holes of one metre in depth, occupied in doing so one hour and nine minutes. It has also been observed in the heading gallery at Goëschenen, that on 4,226 metres of holes, a DUBOIS-FRANÇOIS machine took a time of one hour thirty-one minutes to bore a hole one metre in depth.'

The Kainotomon Rock Drill.—This machine, patented and manufactured by Messrs.

Hathorn and Davidson, may be regarded as a simplification of the Burleigh rock drill (vol. i. p. 456), with which it has many points in common. In the Kainotomon drill the reciprocatory and rotatory motions are alone performed automatically, the feed being given by hand, and thus the tool is not so liable to break on a sudden transition from a soft rock to a harder. See ROCK-DRILL.

DRINKING WATERS. See FILTERS and WATERS.

DUALINE. See EXPLOSIVE COMPOUNDS.

DURRA. The name given in India to the Sorghum, which is much used for food. See SORGHUM SEED.

DUNGING. (Vol. ii. p. 163. See also CALICO PRINTING.) Various substitutes for cow-dung have of late years been introduced. Arsenates and phosphates have been employed. Arsenate of soda appears to have given good results. Crude phosphates prepared by acting upon bone earth with sulphuric acid have also been successfully used, but it is recommended by MERCER to use it in conjunction with gelatine in the shape of bone size.

Silicate of soda has been patented as a dunging substitute. The silicate is made by fusing together 100 parts of silicious sand and and 77½ parts of soda ash, containing 56 per cent. of soda, the fusion to be continued until all effervescence produced by the escape of carbonic acid gas has ceased. HIGGIN patented a process in 1855, which consisted in replacing the silicate of soda by silicate of lime. Arsenate of soda is not said to be extensively employed as a dung substitute. Objections have been raised against the use of an arsenical salt, but the fabrics dyed retain only the minutest trace of arsenic, and that too intimately combined with bases to justify any fears. The greater portion of the arsenic in the arsenate passes away from the works in the waste water. Arsenate of soda may, therefore, be looked upon as a perfectly safe and good dunging salt.

Indeed the silicate and the arsenate of soda are the only substitutes for cow-dung which are at present in use. They answer well, and cow-dung is no longer a necessity in calico printing.

DURANGITE, an orange-coloured mineral found with tinstone and topaz at Durango, in Mexico. Analysis gives the following composition:—

As^2O^5	Al^2O^3	Fe^2O^3	MnO	Na^2O	Si^2O.
55·10	20·65	4·78	1·30	11·66	0·81.

It contains also a considerable quantity of fluorine, but the proportion of this has not been determined.

DYES. (See DYEING, vol. ii. p. 163.) *New dyes from organic substances.*—Messrs. CROISSANT and BRETONNIÈRE, of Laval, Mayenne, France, have produced some new dyes, which promise to be exceedingly useful. They are not very brilliant when compared with the aniline dyes, but they usually have considerable warmth of tone. These dyes are said to surpass in durability any dyes known; they are not in the least affected by acids or alkalis.

The sources from which the new colouring matters are obtained embrace almost all organic substances. The following are especially named:—Wood-sawdust of all kinds, humus, vegetable detritus, lichens, mosses, bran, farina, gluten, starch, fecula, sugar, glucose, cellulose, paper and cotton waste, tannin, gallic acid, gelatin, casein, fibrin, blood, horn, soot, tartaric, citric, and formic acid, and their alkaline salts, resin, aloes, guaiacum, dragon's blood, gum resins, &c. The process by which these dyes are produced consists in the treatment of the organic body to be operated on, with certain sulphides at a more or less elevated temperature, according to the nature of the substances under treatment and the tint required. The process of manufacture is said to be very simple, requiring neither complicated apparatus nor much labour.—ADOLPHE OTT, *Chemical News*, vol. xxx.

A report made on these colouring matters by M. R. GLANZMANN (*Bulletin de la Soc. Ind. de Rouen*, iv., 4th February, 1876) shows that numerous attempts are being made to apply these colours. There is scarcely an organic substance which will not under the influence of soda, sulphur, and heat yield a tinctorial matter, and M. CHAVRERUL reports that those colours produced by the greatest heat are the fastest when exposed to light and air. The method of dyeing consists in working the cotton for half an hour in warm liquor containing a sufficient amount of the colouring matter, wringing out, and working hot for half an hour in a solution of bichromate of potash, washing, and lastly boiling in a solution of carbonate of soda.

M. GLANZMANN continued his researches on these dyes, and especially with a new substance called 'Laval catechu' prepared by the manufacturing chemists POIRRIER. This substance was in large broken masses, resembling partially-carbonised wood, very porous, of a black-blue colour, and emitting an odour of sulphuretted hydrogen.

It was contained in the boxes, and was found very hygroscopic, dissolved easily in water, which when warmed took up the fourth of its weight; beyond that quantity it mixed rather than dissolved in water. The solution was very alkaline, precipitated by all acids, which in excess caused an evolution of sulphuretted hydrogen; concentrated mineral acids separated sulphur from the solution, which, by heat, melted and swam on the surface. The precipitated matter is always of a dark brown colour, and is with difficulty redissolved by alkalies. Most of the metallic salts and acid salts also precipitated the colouring matter either black or dark brown, mixed with the metallic sulphuret and oxide carried down by the alkali. The experiments in printing this colour were not particularly successful, but brought out some new facts, which, however, do not seem capable of receiving an extended application. The experiments were in four series. In the first a colour thickened with starch and containing 4 oz. of the organic sulphuret per gallon was printed. It gave a dull grey. The colouring matter fixes perfectly without assistance of a mordant; simple contact with the fibre is sufficient to dye it. Steaming helps the fixation, for samples steamed were found to lose much less colour in washing out the thickening.

Chroming, either hot or cold, in bichromate at 1 lb. salt to 20 gallons of water after steaming, accomplishes the complete fixing of the colour, so much so, that colour thus fixed appears as dark as after the printing. The goods may also be washed off in weak mineral acids, without changing the colour; alkaline baths also can be used without any injury taking place to the whites. The grey colour resulting resists in a perfect manner the action of light, mineral acids, and soap. Bleaching powder solution has more action: a sample sent through the chloring machine, with chloride of lime at about 1° Tw, lost at least 20 per cent. of colour and became yellower. Upon stronger colours less action takes place. The second series of trials were made with a view of determining the best thickening, and to ascertain the effect of preparing the cloth with mordants.

Three different thickenings were employed—white starch, gum substitute, and tragacanth jelly. Colours containing 1 per cent. of the colouring matter were printed upon unprepared calico, upon calico prepared with acetate of alumina from precipitated alumina at 12° Tw, and upon calico prepared with weak tannic acid. The thickenings with starch and tragacanth gave the best results. The colour thickened with gum substitute does not fix, all disappearing in the washing; this is owing to the acidity of the thickening, which ought to be alkalised before adding the colouring matter.

The preparation of the cloth had not the least influence upon the shades produced. Steaming and chroming have a decided influence in fixing the colour, but in weak shades give a strongly yellow tone to the colours. None of the results obtained by printing are worth anything. The shades have an unpleasant yellow aspect, to correct which it is necessary to wash off in weak acid or in sulphate of copper.

The third series was upon mixtures of the new colouring matter with some other colouring matters soluble in alkalies. Catechu and annatto give some good shades; annatto appears to resist light much better in this combination, since a sample did not lose much colour by eight days' exposure to the sun. The mixed colours must be steamed, and the catechu colours chromed; the annatto mixture may be passed in weak acid after steaming.

The remaining trials were an endeavour to combine this colour with deep blue styles, but the results were not satisfactory. Printed as a crossover, it darkens the indigo where it falls, but the yellow shade of the colour gives a greenish hue to it. By using a stronger blue, steaming, and passing in sulphate of copper, somewhat better results were obtained. The grey partially resists the discharge of oxalic acid and bichromate upon indigo, and some interesting effects can be obtained, but, on the whole, there seems little hope of being able to make any profitable use of this colour in printing.

In dyeing, the prospects are much better, for M. Grassmann says there is no colouring matter known so fast and so easy to apply, and which can give so many different shades. These properties, combined with its low price, make it deserving of attention.

For dyeing yarn, nothing more is required than to dip the cotton a few minutes in a solution of the colouring matter. Wash, and pass in the fixing agent so as to obtain the shade desired. The depth of colour obtained is exactly in ratio with the degree of concentration of the colouring matter, and independent of the volume of the solution, or the total quantity of colouring matter present; and in this respect it differs from nearly all other dye-stuffs.

It is possible to vary the shades by varying the fixing agent, which may be bichromate of potash, carbonate of soda, metallic salts, or weak mineral acids. It is

observed that nitrates and nitric acid give a yellow tone to the colours, while sulphuric acid and the sulphates, especially sulphate of copper, yield bluer tints.

The cotton has always a soft agreeable feel when finished in any of these solutions.

The colour obtained by dyeing at about 170° F. in a solution containing 5 per cent. of the colouring matter, and fixed in bichromate solution at 1 of salt to 200 of water, is a good dark shade. The colouring matter at 3 per 1,000 gives, in the same way, a good light grey of remarkable solidity.

The best shade of grey is produced when the dyeing is finished in sulphate of copper solution, containing 1 per cent. of salt.

By combining catechu in alkaline solution with the colouring matter, and also annatto, some compound shades possessing desirable qualities may be obtained.

The bluish grey obtained by finishing in sulphate of copper may be advantageously used as a basis for dyeing in indigo blue to obtain darker shades with economy. It is not less stable than indigo itself, which is one of its recommendations for this purpose.

These colouring matters appear to have been already extensively used for dyeing in Germany, a manufactory at Goettingen producing them on a large scale, and supplying eighteen different colouring matters obtained from various matters by the sulphuret of soda process.

DYEING, AERO-HYDRAULIC. Mr. G. C. Gruss has patented a process to which this name has been given, which consists essentially in forcing the dye through the fabric, whatever it may be, by hydraulic pressure. By this process all the colours in a pattern are forced at the same time completely through the stoutest materials, or through ten or more thicknesses of calicoes, silk, and similar goods, and the material so treated has no 'wrong side.' Mr. Gibbs claims for his invention that a much better and more durable article can be offered to the public at an actual reduction in cost. As regards carpets, he claims that by the aid of this machine half the expenditure of labour hitherto required can turn out quite three times the length of felt carpet in a given time, as compared with existing processes, and that the carpet so dyed will remain bright until completely worn out, or it may be turned. There is no waste of dye—as in the ordinary process of stamping each colour separately—for every particle of the dye not fixed in the material flows back to the tanks, and is used over again. The machine is specially adapted for dyeing felt. For producing patterns in lighter substances other machines would be designed. The same principle, we are informed, can be applied to tapestry. One great difficulty in working the machine was in not being able to produce two colours of equal density, but by a peculiar arrangement of the valves—by which the dye, which at every stroke becomes partially exhausted, is replenished, this difficulty is practically overcome. Several pieces of extra stout felt having been separately subjected to the process, the impression produced was of almost the same colours on both sides, and when the felt was dried and pressed both sides of the material so treated became exactly similar. Four thicknesses of Bath coating were placed in the machine at one time, and in the two inside pieces the colours were stamped precisely alike on both sides, while in the two outside pieces the impression produced on both sides was so nearly alike that the difference was almost undistinguishable. By this process, too, concentrated dyes are used, whereas by the ordinary system the dyes are very much diluted. The inventor claims that, while hitherto the production of a really good felt carpet has been practically discouraged, as the pattern was simply stamped on the surface, and consequently soon removed by wear, by his process felts can be utilised which will equal in durability any other description of carpet, with the special advantage of remaining bright to the last. The machine already erected delivers more than 12 square feet per minute, and larger machines, Mr. Gruss states, could dye fully double this quantity.

DYEING. *Aniline Blacks on Cotton Yarn.*—This process requires great care to prevent the blacks from being clouded. (1.) The cotton-yarn, well boiled out, receives seven turns in a bath composed of 200 grms. of sulphate of copper for every kilo. of chloric acid. It is then well wrung out. (2.) It receives five turns in a bath at 50°, containing 50 grms. hydrosulphate of soda per litre, and is rinsed. (3.) It receives seven turns in a bath of 10 litres of water, 180 grms. chlorate of potash, and 170 grms. sal-ammoniac, dissolved in heat, and then mixed with 480 grms. chloride of aniline. (4.) It is stretched out very regularly in a hot drying-room at 24° for 48 hours. (5.) Lastly, it receives four turns at 30° in a bath containing 1 grm. bichromate of potash per litre, and is well rinsed and dried. If the blacks are reddish, they may be passed through a bath containing 1 litre bleaching liquor at 6° to 100 litres of cold water.—*M. M. de Vinant.*

Pearl-grey with Aniline Violets.—Aniline violets applied in very feeble tints furnish pearl-greys, whose tone varies with that of the violet employed, and is pure in proportion to the excellence of the dye. As the quantity of colour employed is very

small, only the highest class of aniline violets should be employed. Cotton may be dyed without mordant. The bath should contain a little soap, without acid, though a very small quantity of tartaric or acetic acid is added at the end. For pure wool the colour is dissolved in lukewarm water alone without acid.'—*Chemical News.*

Dyeing with Eosine.—This colouring matter is coming generally into use. Lead is the best fixing agent for it on cotton. The calico is printed with a solution of eosine thickened with gum, steamed, and then fixed with acetate of lead. This gives more crimson or purple shades than when the colouring matter is fixed directly with albumen.

In silk dyeing, the eosine in water does not give very good results; the dark colours produced are detached by rubbing. A solution of eosine in alcohol produces a fine primrose which is not thus removed. The best proportions are, that modification of eosine which is soluble in alcohol called 'primrose,' 1 lb., alcohol 12 lb., water 5 lb., and ½ lb. carbonate of soda. These are to be heated together in a water bath. The silk is best dyed in water containing the soapy liquors from the silk bleaching acidified by acetic acid, raising gradually to the boil, washing, brightening with some organic acid, and dyeing. These colours are very permanent, and far exceed in beauty similar colours obtained from safranine.

On wool, eosine gives cochineal-like shades, but it cannot compete with the true cochineal colour, unless it be for the lighter shades. Wool dyes with it at 140° Fahr., adding alum at the rate of 5 per cent. of the weight of the wool. (See Wool Dyeing.)—*The Textile Colourist.*

Dyeing Raw Hides.—The following is a description of the process as it has been introduced by the National Boot and Shoe Tip Company, of Boston, U.S., by whom the process has been patented. It should be first explained that they propose the use of these dyed hides for the making of shoe tips to supersede the copper tips usually employed.

The raw hide from which tips or protectors are made is unhaired, unfleshed, and rinsed in the usual manner, and after being removed from the rinsing vat is prepared for colouring by being run through a lukewarm logwood liquor. The hides opened out flat are laid one above the other in a vat containing enough of this lukewarm liquor to cover and saturate them, as it has been ascertained that the logwood liquor acts the most rapidly and produces the best results when about lukewarm. Then the hides so treated are soaked in a dyeing liquor composed of logwood liquor, nut-galls, blue vitriol, vinegar, and an iron set.

The hides, after being properly dyed, the colour being a deep black, and permeated through the entire substance of the hide, are stretched, dried, and polished. Then to manufacture the tips or protectors the hide is moistened and cut by dies into pieces of the form desired, the pieces are moulded or shaped in moulds and are then dried, when they may be polished, if desired, the hide treated and dyed as herein described being capable of taking a deep black, and the tip or protector when formed will be hard and susceptible of taking a polish much like hard rubber.

In dyeing the hide the patentees make use of two solutions besides the logwood liquor. Solution No. 1 is made by boiling together, for five or ten minutes, four ounces each of pulverised nut-galls and blue vitriol in a gallon of hot logwood liquor, and afterwards adding four quarts of vinegar saturated with iron in the well-known way, or the chemical equivalents of the vinegar and iron may be used. Solution No. 2 is an iron 'set' made by dissolving iron chips in aquafortis or other acids, the iron being added until a saturated solution is obtained.

For the purpose of thoroughly blacking about half a dozen hides or two or three dozen medium-sized skins, place the hides which have been previously soaked in logwood liquor, in about twenty-four gallons of logwood liquor, such as that first described, and to which has been added about two quarts of the solution No. 1, and about one pint of No. 2 solution, the latter solution having a tendency to set the colour or cause it to penetrate the hides. The hides should be allowed to remain in this dye liquor from one to three days, according to their thickness, they being frequently turned to secure a thorough penetration of the dyeing liquor into the hides. It may be remarked that the exact quantities above given are arbitrary, as the ingredients vary in strength, and some hides will take colour more easily than others. The quantities mentioned will generally be sufficient to blacken two dozen calf-skins or a half dozen kips or light cow hides, but the heavier hides require to remain longer in the dye liquor. The dyeing liquor only requires to be replenished as its strength is exhausted by the addition of fresh material to keep it in substantially the proportions just described. Maroon and purple colours may be made by working in the logwood liquor, and finishing by using aquafortis and tin with solution of logwood, instead of the dyeing liquor above described.

Raw hide, after being subjected to this treatment, in which it is only partially

tanned, is rendered a deep and permanent colour throughout its substance, is better capable of resisting moisture, and is susceptible to a high polish, giving it a neat and finished appearance similar to that of hard black rubber. It can be prepared at exceedingly low cost, does not become rusty or discoloured by use, but retains its original neat appearance until completely worn out, and is thus of great value in the manufacture of tips or shields for the toes of boots and shoes, and of similar or other articles liable to rough usage.

Imports of Dye Stuffs.

	[illegible]		[illegible]	
	Cwts.	Value	Cwts.	Value
From Holland	3,995	£11,701	11,849	£140,225
" Belgium	2,760	35,317	3,037	22,327
" France	46,463	140,625	39,495	112,002
" Portugal	5,307	11,578	4,192	9,030
" Spain and Canary Islands	7,081	17,035	10,604	18,772
" Italy	3,415	11,725	—	—
" Turkey	5,029	34,015	4,496	10,951
" U. S. of America	31,402	61,180	24,398	47,484
" Mexico	17,419	26,571	11,309	24,084
" New Granada	25,735	21,080	40,179	27,778
" British East Indies	19,457	16,966	34,157	32,732
" Other Countries	13,791	25,833	29,052	45,204
	182,049	413,442	213,021	511,569

Imports of Dye Woods.

Logwood.	Tons	Value	Tons	Value
From U. S. of America	—	—	1,742	£13,554
" Hayti and St. Domingo	2,486	£12,998	2,161	14,609
" Mexico	1,876	16,728	924	8,654
" British West Indies	32,256	172,968	44,982	296,383
" British Honduras	5,710	26,832	5,190	37,019
" Other Countries	1,141	9,888	1,169	9,593
	43,471	236,434	56,168	379,712

Imports Unenumerated.

	Cwts.	Value	Cwts.	Value
From France	—	—	1,264	£9,716
" Africa, West Coast	2,217	£13,498	3,565	23,071
" Philippine Islands	703	6,569	726	7,125
" U. S. of America	1,145	9,234	2,212	19,853
" Mexico	1,377	15,170	4,600	41,166
" New Granada	1,224	12,022	1,823	14,417
" Venezuela	—	—	1,366	10,403
" British East Indies	2,387	20,469	2,572	22,966
" British West Indies	3,555	21,962	5,822	40,039
" Other Countries	3,400	25,058	4,314	34,528
	16,023	123,912	28,244	225,361

DYNAMITE. (See vol. ii. p. 170, 7th edition.) The following is the authorised statement respecting this explosive compound, which is now being sold under the name of 'Giant Blasting Powder.' The only dynamite licensed is specified in the license granted as follows:—

'Dynamite consisting of thoroughly purified nitro-glycerine, thoroughly mixed with not less than 25 per cent. of an infusorial earth known as "Kieselguhr," and sufficiently absorbent in quality to prevent exudation of the nitro-glycerine;' and the

following observations therefore relate only to dynamite of that particular composition and quality.

'The risks to which explosives are liable in transport may be grouped into—(*a*) Risks from without. (*b*) Risks from within.

'Risks from without include the following:—(*a*) Explosion by fire from adjacent conflagration or explosions. (*b*) Explosion by sparks. (*c*) Explosion by wilful incendiarism. (*d*) Explosion by lightning. (*e*) Explosion by collision.

'It must be assumed that the same protection against these various risks would be provided in the case of dynamite as at present exist in the case of gunpowder; and the former explosive would certainly offer no greater attraction, so to speak, to external risks, than gunpowder.

'As in the event of any of the foregoing external risks overcoming the protection provided against them in the case of gunpowder an explosion would follow, it is obvious that no worse consequences could follow in the case of dynamite.

'But there are good grounds for believing that, with regard at least to some of the external risks, the consequences might be less serious with dynamite than with gunpowder.

'For example: it is known that a considerable quantity of dynamite may be burnt without explosion, while, in the case of gunpowder, even a few pounds, if ignited, will produce an explosion more or less serious, according to circumstances.

'Again: a collision which would almost certainly produce an explosion of gunpowder would be far less certain to produce an explosion of dynamite, which is a plastic body, and which thus, when present in any mass, absorbs a good deal of the energy of a given blow by virtue of such plasticity. Again, while a single grain of gunpowder exploded in contact with other grains, or (unless artificially or sufficiently separated therefrom) in close proximity thereto, would certainly explode the whole, such a result would by no means certainly follow in the case of the explosion of a particle of dynamite under similar conditions.

'It appears, therefore, that with regard to the liability to accident from external causes, dynamite of the specified composition and quality is somewhat less dangerous than gunpowder in barrels.

'Risks from within include the following:—

'(*a*) Accident from fire-giving or explosion-producing agents.

'(*b*) Accident from spontaneous ignition or explosion due to (1) the presence of foreign substances, or (2) to the chemical instability of the explosive itself.

(*c*) Accident from sparks.

'(*d*) Accident from friction or percussion.

'(*e*) Accident from elevation of temperature.

'Such articles as would explode dynamite would certainly explode powder; but on the other hand, some articles which would explode gunpowder would probably not explode dynamite.

'With regard to *pure* dynamite, such experience as has accumulated with regard to that substance has been increasingly favourable, and has tended to show that the substance is possessed of the requisite chemical stability.

'A spark which would fire dynamite would certainly explode gunpowder; on the other hand, it is far from certain that every spark which would explode gunpowder would easily fire dynamite; while it is possible, as above stated, for dynamite under certain conditions, and in moderate quantities, to be fired without being exploded.

'It may, therefore, be taken broadly, that *"dynamite" of the specified composition and quality is, on the whole, safer to transport than gunpowder packed in barrels.*'

There has been a popular belief that frozen dynamite is more liable to explosion than in an unfrozen state. The British Dynamite Company employed Professors James Thomson and Bottomley, of Glasgow, to make a series of experiments, and the following is their report:—

'At your request, we were present at experiments made on the sands at your works at Stevenston, Ayrshire, with a view to proving that dynamite in a frozen state is as safe to handle and to transport as in an unfrozen state.

'*First Experiment.*—Several cartridges in a frozen state, and in some parts beginning to thaw, were thrown one by one from the hand, with great force, against an iron plate, in the manner in which snowballs are thrown in a vigorous encounter. The cartridges were squeezed partly to lumps sticking to the plate, and partly were smashed to fragments which flew round about, but there was no explosion.

'*Second Experiment.*—A block of iron, about 400 lb. weight, was allowed to fall from a height of about 20 feet on a light wooden box containing 20 lb. of dynamite cartridges in a frozen state, and with slight signs of incipient thawing in spots more exposed to the warmth of the air. The box was smashed, and the cartridges were crushed flat and pounded together, but there was no explosion.

'Both before and after the operation we inspected and handled the cartridges, to make sure that they were frozen. We ascertained this by finding them hard, dry, and friable; and by finding besides, after the fall of the weight, that on breaking up pieces of the crushed and compressed cartridges, and holding them for some time in our warm hands, they melted and became moist and soft, so as to work in our hands like putty or wet clay.

'*Third Experiment.*—The crushed cartridges were next made up into two heaps, and placed on the sand to be exploded. This was effected by inserting among them a small unfrozen cartridge, or "primer" of dynamite, with the ordinary detonator inserted into it, and then firing this off by a Bickford fuse. The reason for employing the unfrozen primer to get the frozen cartridges to go off, was explained as being that the frozen dynamite is so difficult to be made to explode, that even the ordinary detonator fired within it, although shattering it, fails to set it off; but that an unfrozen cartridge or primer exploded by the detonator communicates its explosion to the frozen dynamite. The two heaps of crushed, frozen cartridges were only a few yards apart. They were exploded successively, and it is worthy of remark that the explosion of the first, though very violent, did not set the other off. That second one, however, also made a very violent explosion when ignited with the aid of the detonator and unfrozen primer.

'We were much satisfied with the manner in which the experiments were shown to us, and we consider that the tests we witnessed on the frozen dynamite were very severe.'

The following instructions for charging bore holes with dynamite have been issued by the Company, and they should be most carefully attended to:—

'1. A *wooden rod or squeezer* should be used to push home the cartridges in the bore hole. *Never use a metal rod or rammer.*

'2. *Never ram or pound* the charge home. It should be gently, although firmly, squeezed into its place.

'3. Never squeeze the primer containing the detonator; but lower or push it gently until it rests on the charge.

'4. Use sand or water tamping.

'Be sure you fix the percussion cap tight on to the fuse with your nippers, and in wet holes make it water-tight with grease, white lead, tar, or whatever else you may have handy.

'Be sure you do not push the cap overhead into the dynamite cartridge, or the fuse will set it on fire, and burn and waste the dynamite, as well as cause a smell. To avoid this, let a quarter of an inch at least of the cap remain outside the substance of the dynamite when you fire a shot, and you will have the full power of the explosion without any loss of force.

'Be sure, when blasting in what are called close workings, to attend to the above, as in such places, whether you employ gunpowder, dynamite, or any other explosive, it is impossible altogether to avoid causing fumes. This is true, whatever may be said to the contrary.

'The patentees assert that in dynamite you have the strongest and safest, the most handy, and the most useful explosive for mining and quarrying purposes that has ever been discovered. Whether for sinking pits through the hardest, wettest, or driest ground, or working mines in the wettest and most difficult places, dynamite has shown itself to be equal to your requirements, and has done for you what no other explosive could do.

'As an industrial explosive it is stronger, cheaper, and safer than any other blasting agent yet discovered.' A further trial is necessary to confirm this positive statement.

The following extracts, from a pamphlet bearing the title *Assemblée Nationale, année* 1873. *Rapport fait au nom de la Commission chargée d'examiner le projet de loi fixant le prix de vente de la poudre Dynamite*, are given as an addenda to the report already printed on the tendency of dynamite to explode:—

'Dynamite is, it is true, only a transformation of explosive oil, but in a state which, whilst preserving all its power, *renders its employment and carriage much less dangerous than gunpowder.*

'Dynamite, already utilised throughout Europe, would undoubtedly be still unknown in France but for the publication, at the beginning of 1870, of a translation made by M. Barbe, of documents published by M. Nobel.

'Utilised at Paris during the siege, under the encouragement of the Minister of Public Works, it was likewise manufactured in the provinces for the requirements of defence and for use in mines.

'Its employment had become general, and our mining industry supplied itself from the Paulille Works, when the administration of indirect taxes laid an embargo on that establishment.

'The advantages of this product are no longer open to question. The Administration of Finance have themselves admitted the necessity of placing it at the disposal of trade. We cannot say what may be reserved for this substance in the future, but it will suffice to recall the diversity of its employment in order to fix our attention upon the interest which it would seem to justify.

'*Employment of Dynamite.—The War Department* has been favourably impressed by the use which may be made of it in a campaign, and we owe to the anxious care of our eminent colleague, General de Chabaud-La Tour, President of the Committee of Fortifications, a remarkable work on the theoretical and practical study of dynamite, and the conclusions of the author of this work, Captain Fritsch, are absolutely favourable to its use in the army.

'*The Navy* also are giving their attention to the various ways in which this product may be used. The Pyrotechnic School at Toulon has already made numerous experiments with the aid of dynamite, supplied by private establishments. These experiments are still going on; they will certainly lead to the use of dynamite in torpedoes, although at present these explosives are still charged with common powder, or with powder having a basis of picrate of potassium—powder which, it may be observed in passing, is manufactured at private works without any question on the part of the collectors of indirect taxes.

'Experiments recently made by the Commissions of Calais and Bourges with special dynamite, also supplied by private works, have shown that the dynamite used in charging shells might, without any inconvenience, bear the highest initial rates of speed (from 5 to 600 m. per second), whilst still preserving a sufficient power and facility of inflammability.

'In the department of *Public Works*, the engineers and contractors are constantly seeking for this powder, which they cannot procure upon favourable terms. Considerable reductions would be submitted to by contractors, who would find in the use of dynamite an economy of time, labour, and advantages which cannot be obtained by means of gunpowder. The opening of tunnels and subaqueous works are in fact effected with about half the expenditure of time; holes for mining are more rapidly executed by reason of their reduced diameter, the inutility of ramming, and the action upon a larger mass.

'With regard more especially to subaqueous works, as dynamite will detonate, notwithstanding its contact with water, it has an incontestable advantage over all other powders. It is used for the destruction of rocks under water, the demolition of wrecked vessels, the breaking up of ice, removal of bridge piles and culverts, &c. &c.

'Industry is still more immediately interested in the bringing into play this new agent for the extraction of ores and coal, the boring of wells, the breaking to pieces of castings, and the resumption of ancient works that have been abandoned through want of sufficiently powerful means of extraction, or in consequence of the increased rates of wages for hand labour.

'*Agriculture* also is not indifferent to its being brought into more common use. In the Department of La Manche, for instance, very important quarries of a silicious and extremely hard marble, capable of being turned to account in the making of an excellent rich lime, which cannot be worked by the aid of ordinary mining powder, will yield, with the assistance of dynamite, results that allow of the sale of the lime at the rate of 10f. per ton in a country otherwise unprovided with calcareous products.

'The considerable number of petitions addressed to the National Assembly by manufacturers and large mining companies, as to the urgency of determining acceptable conditions for the employment of this new agent of labour, sufficiently prove the powerful interest which industry attaches to its use.

'*Conditions of Relative Safety in the use of Dynamite.*—Is this product, which seems to results so many manufacturing advantages, dangerous in carriage and employment? We are enabled to affirm that upon this point also dynamite is very different to the chlorates, picrates, phosphorus, cyanures, &c. &c., which have all been tested with such cost to those who have ventured upon the use of them. *It is even less dangerous than ordinary gunpowder*, for its conditions of inflammability are very different; the fire from a match will not explode it, and a special priming is needed to make it produce all its detonating effects.

'*We can assert that it offers no danger in the carriage*, if an experience of ten years in all the countries which make use of it and allow of its free manufacture be sufficient to give us confidence. In Prussia, in Italy, in Spain and Austria, where its transport is openly effected by rail, it has been proved to be less dangerous than ordinary powder.

'Our railway companies were of the same opinion, inasmuch as they conveyed the

products of the Paulilles Works, as we have ourselves verified by the way-bills accompanying the consignments of dynamite upon the Midi, Est, and Paris-Lyon-Méditerranée lines, &c.

'*Experience has proved down to the present time that the danger of its carriage becomes nil so long as the priming by which it is ignited does not travel with it in the same carriage.*'

Dynamite has been extensively employed on the Continent and in America for removing the roots of large trees from the soil. The following description of the actual use of this explosive in clearing land will be read with advantage:—

Mr. David Craig, of Four-Mile Burn, near Dough, Ireland, had a number of very large beech trees which he wished removed, as their roots interfered with his farming operations, and their widely-spreading branches prevented the sun shining on what was growing beneath. They had been planted 120 years ago, in good soil near the Burn, which must have considerably aided their growth, for some of them measured up to 12 feet in circumference at their base, and were over 60 feet high. Mr. Craig had some of them cut down, but great labour ensued in getting the stumps removed. He tried gunpowder and guncotton powder in different ways to break them up, but both these explosives proved quite insufficient. When, however, by tedious manual labour a stump was split up, he had in some cases to employ horses, attached to a long lever, to aid in twisting the roots out of their bed. Owing to the expense, trouble, and delay in getting on with the work in this method, and hearing of the advantages of using dynamite in such cases, he applied to the British Dynamite Company's agents for Ulster, who arranged to send him a man who understood the proper mode of applying dynamite to all such obstructions.

On the appointed day the Dynamite Company's instructor went to Mr. Craig's, and in one day cleared the ground of all the remaining tree stumps, besides a number of growing trees which he wished removed, bringing them up 'root and branch' out of the ground, greatly to the satisfaction of the proprietor and amazement of all who had assembled to witness these operations.

The mode of uprooting the trees was as follows:—In the ground underneath the trunk of the tree to be removed a hole was made with a crowbar, and into it some cartridges of dynamite were pressed with a wooden rammer, then a detonating percussion cap was squeezed on one end of a Bickford's fuse and inserted into a cartridge of dynamite; this was then placed in contact with the charge under the tree; some earth was next applied to close up the hole, leaving about one foot of the fuse extending out. All being ready, a match was applied to the fuse, the powder in which slowly burned till it reached the 'detonator cap' at the other end, which the fire caused to explode, and that in turn exploded the charge of dynamite.

The result was that all the earth immediately underneath the tree's trunk was cleared away, and the small roots torn up and broken; and in cases of such large trees as were operated on, from four to eight large roots, of about ten inches in diameter each, only remained to support the tree. Some of these were next blown away by small charges of dynamite inserted under them a few feet distant from the trunk. The tree then falls on the side from which the supports are removed, its weight at the same time assisting in tearing up and breaking the roots on the opposite side.

The agent, having thus brought down the trees, showed how large boulder-stones up to 50 tons weight may be broken into pieces without the labour of boring being necessary. This was done either by placing a charge of dynamite close underneath the stone, in a hole made with a crowbar, and firing it as stated above, or by pressing some cartridges on top of the boulder, and covering them over with earth, and firing the charge with the detonator and safety fuse in the usual way. Rocks cropping up through the soil can be reduced in a similar manner. In many farms great inconvenience is felt by such obstructions, which now can easily be cleared away by this valuable agent. See Explosive Compounds.

MM. Girard, Millot, and Vogt report, in the *Moniteur Scientifique*, xiii. 59, some good experiments on the relative explosive powers of nitro-glycerine and various kinds of dynamite, and in the same journal M. P. Champion has a paper on the use of dynamite in war.

M. Sobrero has communicated to the Académie des Sciences the result of some experiments made in the manufacture of dynamite cartridges. While acknowledging the importance of M. Nobel's idea of giving to nitro-glycerine the consistency of a solid body by causing it to be absorbed by a siliceous substance, so as to be more easily employed in mines, M. Sobrero has always been struck with the frequent occurrence of explosions in dynamite factories. He has often thought that these accidents, the details of which are very imperfectly known, may be caused by the manipulations which take place, either in preparing the paste of nitro-glycerine and

the absorbent substance, or in moulding and compressing the paste for giving it the form of cartridges. Compression and friction against hard substances are so many causes which easily bring about an explosion of nitro-glycerine. It seemed to M. [illegible] that these causes of danger might be avoided by modifying the manufacture of dynamite in the following manner:—The siliceous substances, of the nature of kieselguhr, &c., although only slightly plastic, are capable of being moulded after moistening with a little water, and take a consistency which is not inferior to that of dynamite cartridges. He made some cylindrical cakes with Santa Flora fossil meal, which after being dried at 100° Cent. (212° Fahr.) to get rid of the water, were plunged vertically into the nitro-glycerine, so as to become saturated therewith. The experiments to determine the quantity of nitro-glycerine which cakes were capable of absorbing were not made with liquid itself, for fear of accident, but with olive oil, which is nearly of the same consistency. The author is convinced that dynamite with 75 per cent. of explosive substance, as is generally required, may readily be obtained by his process; while at the same time all violent pressure or friction is avoided. The cakes, after leaving the bath of nitro-glycerine, have only to be placed to drain, and then wrapped in paper, when they are ready for use.

Dynamite in Land Clearing.—An account was recently given of a number of experiments performed in the woods and fields on the Cadder estate of Sir William Stirling-Maxwell, and near the Forth and Clyde Canal, on the farm of Mr. John Murdoch, of Hilton. Their object was to show the great utility and advantages of this dynamite in the clearing of land so as to fit it for cultivation, and they were intended chiefly for the benefit of several gentlemen who are largely interested in land clearing and agricultural operations in Canada. Having shown that the ordinary method of inducing explosive action in gunpowder was not sufficient to bring about an explosion of dynamite, it was explained that the new explosive had this peculiarity—that it would only do its work—that of decomposing with explosive action—when it was powerfully percussed, and that the ordinary method was to explode some detonating or other explosive substance in contact with it. Specially prepared and extra-powerful percussion caps are the agents used to induce the explosion, and with these it is customary to use, especially in water-bearing rocks and in subaqueous blasting operations, a suitable length of Bickford's fuse. After performing some preliminary operations, attention was turned to the root stumps of a number of trees that had recently been cut down. By means of an auger a hole about 1¼ in. diameter was bored vertically to a depth of of 12 or 15 in. in one of the stumps, and when it was found to be quite through the wood of the stump it was continued by means of a punch to a depth of fully 2 ft. Two or three cartridges were put into the bore-hole and firmly driven home by means of a wooden rammer. Then a small cartridge called a 'primer,' prepared with a cap-tipped fuse, was dropped in and rammed home, and the hole was tamped or stemmed by filling it to the top with water, care having in this case been taken to put a luting of clay round the junction of the cap with the fuse. The latter was fired, the observers betook themselves to a respectful distance, and in a brief space of time a great upheaval occurred. The noise of the explosion, however, was in a great measure smothered. When the members of the party returned to the spot they found the stump to be rent in a most extraordinary manner; but the general opinion was that the bore-hole had been made so deep that the energy of the explosion had spent itself too much upon the subsoil and too little upon the wood. The stump next operated upon was bored to a less depth, and the result of the blasting process was more effective. In either case a few strokes with an axe, by way of severing the principal root members, would be quite sufficient to leave the woody masses in such a condition that they could easily be dragged out and lifted away. It was suggested that the operation of piercing with an auger should be dispensed with in blasting the next root stump, so as to do the work with as great economy of time as possible. In this instance, therefore, the punch was brought into requisition instead of the auger, and by means of it a hole was driven horizontally inwards between two of the principal root-members to about the centre of the stump. The hole was charged and fired in the usual way, the result being a much greater amount of eruptive and disruptive action, with a smaller expenditure of time and labour. One or two other root stumps of large size were blasted in the same way, and it was clearly demonstrated that, under certain circumstances, dynamite could be employed to more advantage immediately underneath rather than in the mass of material to be operated on.—*Glasgow Herald.*

DYSODILE. (Vol. ii. p. 178.) The paper coal from Sicily has been long known. A characteristic specimen from Rott, near Bonn, was analysed by Professor A. H. Church. The following figures contain the chief analytical data from which the ultimate composition of dysodile may be deduced:—

A.—Dysodile thoroughly washed with water and hydrochloric acid and dried at 100° C.:

0·226 grm.	gave	0·1010	grm.	ash,	or	50·00	per cent.	ash
0·323	,,	0·0980	,,	Fe^2O^3,	,,	25·88	,,	Fe^2O^3
0·651	,,	0·0555	,,	$BaSO^4$,	,,	1·17	,,	S
0·593	,,	0·7515	,,	CO^2	,,	34·56	,,	C
0·593	,,	0·2835	,,	H^2O	,,	5·03	,,	H

Professor Church gives the composition of dysodile as—

Carbon	69·01 in 100 parts
Hydrogen	10·04 ,,
Sulphur	2·35 ,,
Nitrogen	1·70 ,,
Oxygen	16·90 ,,

He therefore infers that this mineral does not belong to the same group as tasmanite, which consists of—as analysed by Professor Church—

Carbon	79·34 per cent.
Hydrogen	10·41 ,,
Sulphur	5·32 ,,
Oxygen	4·94 ,,

Chemical News, vol. xxxiv., No. 881.

Brown coal occurs in the Ries district in strata. Dysodile occurs at the same depth as the brown coal, but only in thin layers in the form of black tough leaves, which become brown on being dried. These leaves are united by a tough loam, which causes the layers to attain a thickness of some centimètres. From these layers thin leaves of dysodile can be separated by a knife. Dysodile is characterised by burning freely with a bright luminous flame, which smells much like burning caoutchouc.

If dysodile is submitted to distillation, water comes over at 50° C., and is eventually driven off. At 170° C. a large quantity of illuminating gas is given off, which contains traces of sulphuretted hydrogen and about 2 per cent. of carbonic acid; at from 220° C. to 290° C. tar comes over in deep yellow drops. Dysodile coke retains the parchment-like appearance of the original substance. 100 parts of crude dysodile dried at 100° C. gave—

Ash	59·464
Carbon	19·353
Hydrogen	3·32
Nitrogen	0·189
Sulphur	0·601
Oxygen	5·843
Water	0·73
	100·000

Rath. Pumpelly, *Jahrb. für Min.* 1875.

DYSS, ALGERIAN. A grass similar to esparto, which grows in many parts of Algiers. It is not so good as esparto, but is used for the same purpose—paper-making. It is said to produce an inferior description of paper, and there is a great deal of waste. It does not, therefore, command the same price as the esparto grass; the esparto from Tripoli and Gabes varying from 5*l.* 10*s.* to 6*l.* 10*s.*, and Spanish 9*l.* 15*s.* to 11*l.*; while the Algerian dyss fetches only from 3*l.* 10*s.* to 4*l.* 10*s.*

E

ELÆOCOCCA OIL. An oil extracted from the oil tree of China. See Oil, Tung.

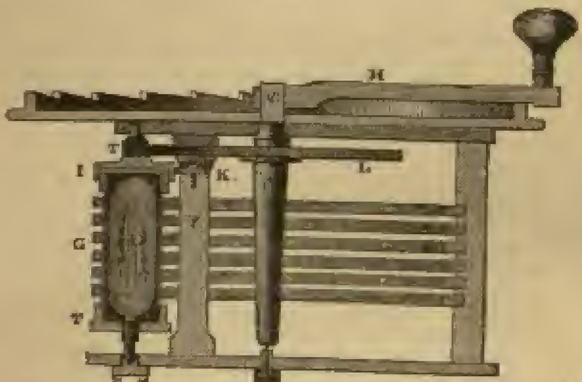
ELDER BERRIES. Solution for adulterating wines. See *Tromie de Fismes* and Wines.

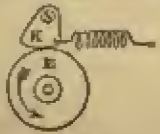
ELECTRICITY FOR BLASTING. (Vol. ii. p. 106). The principle involved in the use of electricity, as a means for firing explosive agents underground, has been fully explained in the article referred to. It must be admitted that electro-blasting has not made much progress within the last few years. We believe this

arises from the *small* difficulties which have to be overcome, and which, small as they are, are not attended to by workmen, who cannot see any necessity for being very exact about trivial matters, which appear to them to be of but small moment.

In order to turn to account all the advantages which electricity offers, it is obvious that, wherever it can be employed, a good practical electric telegraph system, worked exclusively by induction currents, and consisting of simple dial or finger-key dial instruments, must be considered as an indispensable auxiliary to the exploding apparatus. It is evident, too, that the operator at the central office or station from which the exploding currents are sent to the distant shot-holes or mines must be able to communicate with the men in charge of those mines, no matter what may be the distance, in order to warn them in time of the imminent explosion; and again, the miners must be able to communicate to the central station the intelligence that the mine is ready to be exploded, the number of mines or shot-holes, and also the results of an explosion. All the instruments used for this purpose must be of solid construction, and unfailing in their effect, while the source of electricity actuating them must neither be influenced by atmospheric electricity nor be alterable in its intensity, as are hydro-electric currents. *Fig.* 2329 shows the general arrangement of a simple apparatus, designed by Messrs. Siemens and Halske, and recommended for use in telegraphing underground; while *fig.* 2330 is a vertical section of the transmitting instrument. The handle H is fastened to the spindle A, carrying the tooth wheel L,

2329





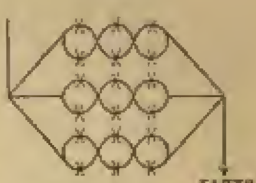
2330

which latter gears into the pinion T of the cylindrical armature or keeper, K. This armature is mounted vertically upon pivots between the poles of a series of permanent magnets, G. One revolution of the wheel, L, or of the handle, H, fixed thereto, causes the pinion of the armature, K, to revolve thirteen times, as the teeth of the former are in the proportion of thirteen to one of the latter. As one full turn of the armature produces two currents of opposite directions in a coil of insulated wire forming part of the cylindrical armature, twenty-six currents, alternately positive and negative, are generated at one revolution of the handle. The dial is divided into twenty-six parts for twenty-five letters of the alphabet (I and J being taken as one) and one blank.

As the places in large mines where rocks or coal seams to be cleft by the explosion are not always of the same nature and dimensions, and as the connecting wires are generally spoilt in the operation, two distinct conducting lines must be employed; first, permanent conductors, following the underground workings of the mine or the line of posts on the surface, as the case may be, and of the best construction and materials; and, secondly, unfixed or flying lines, of the shortest possible length and the cheapest materials, so that their being spoilt by each explosion is a matter of slight monetary importance.

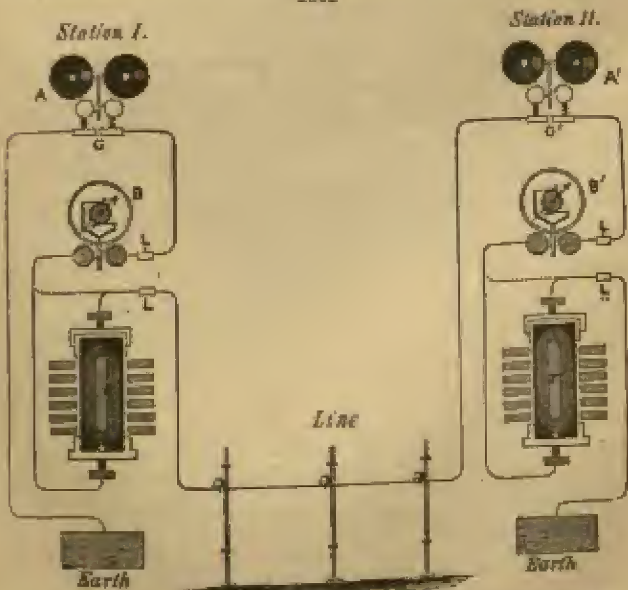
When the telegraph and exploding lines are on the surface, they are attached to patent iron telegraph posts, and consist of compound wire, which allows of a spacing of the posts 500 yards apart, thus considerably diminishing the cost; but if the lines are carried underground small cables are employed generally composed of a strand of three copper wires insulated with several layers of indiarubber and tarred hemp, and protected by galvanised iron wire wound with a slight spiral round the outside. In order to prevent any failure in the effect, Messrs. SIEMENS and HALSKE's method is to connect, for each mine to be exploded, three cartridges with metallic conductors—on ABEL's system—with the corresponding cartridges of the next mine (*fig.* 2331); so that if the currents sent by the exploding machine should, from any defect or want of uniformity in the cartridges, not produce the exploding spark on entering at one end of the mine, it would certainly produce it when entering the other end on the return circuit. This arrangement is adopted because in no manufactory of cartridges in the world can there be a guarantee that the distance between the two conducting wires be mathematically the same; but by using three cartridges in each mine it is almost impossible for the spark to miss.

2331



There are two appliances for igniting cartridges in shot holes, both based on the dynamo-electric principle discovered in 1851 by DR. WERNER SIEMENS. Instead of permanent magnets, a horse-shoe electro-magnet, formed of soft iron, is employed, possessing only a feeble initial magnetism, proper to all soft iron, by virtue of the earth's magnetism. The armature consists of a SIEMENS' coil, which is composed of soft iron of double T section; which becomes a transverse magnet of an intensity corresponding to that of generating electro-magnets. The hollows or recesses in the double T irons are filled in by a coil of insulated copper wire. When a rotary motion is given to this coil, induced currents are formed which increase the initial magnetism of the electro-magnets, and, consequently, the magnetism of the armature; in this way the current becomes intensified. By means of a special commutator, all dissipation of the current along the wire communicating with the

2332



cartridge is prevented; and dynamic electricity is thus produced until its intensity becomes so great that the spark of interruption generated between the metallic conductors of the cartridge attains a certain force. This result is ensured after

three turns of the handle, which, therefore, permits of the simultaneous explosion of as many as a hundred cartridges at once, connected by conductors, provided that the total electric resistance outside the apparatus be equal to that within.

The second application of the principle produces electricity in quantity, and cartridges are used which are exploded by wire heated to redness merely by the passing of the current. The apparatus is similar to that above described; but the firing is effected by hand so soon as the current has acquired a sufficient quantity of electricity.

SIEMENS *and* HALSKE'S *Mine Signal* is an appliance for giving bell signals between the bottom of a shaft and the several heights of workings (*fig.* 2332). It is quite independent of batteries, and consists of a magneto-electric induction machine producing alternate currents, and connected by a special cable with induction bells, A. The inductor contains six permanent magnets, between which a SIEMENS' armature, B, is made to revolve by means of a handle, thus generating currents which act upon the bells. This system does away with the difficulties and shortcomings of bells worked by batteries, as the magneto apparatus is of constant and unchangeable power, is portable and protected against damp, and is not so liable to be damaged by rough handling as battery arrangements are. To give a signal to the distant bell, it is only required to turn the handle of the inductor at the place from which the signal is sent. When two instruments are connected signalling can take place from both ends; but, in cases where signalling is required only towards one end, the alarum-bells can be separated from the inductor and placed at the receiving point while the inductor stands at the sending end.

ELECTRIC CONDUCTORS. A statement has been made, apparently upon authority, to the effect that cast-iron pipes of several feet in length, and with collars nearly three times the diameter of the pipe cast thereon, like the pipes used for heating purposes, have been used with good results as distributors, deep in the earth, of electricity brought down by lightning conductors. The directions are as follows:—

A length of copper pipe, about four times the diameter of the lightning conductor, being fixed in the top of the iron pipe, stands some distance therefrom, and partly above ground. Below the distributing flanges a pointed and perforated cast-iron pipe is attached, the length of the whole of the pipes being about 30 ft., and the conducting rod penetrating nearly to the bottom of the lower pipe.

There can be no doubt but that an arrangement of this description will prove very effective in carrying off any quantity of electricity, which may pass through a conductor of the electric fluid. But it has been proved that a copper pipe sunk a few feet into moist earth, or connected with flowing water, is, for all practical purposes, quite efficient.

M. E. SAINT EDME suggests that instead of platinised points for lightning conductors, which have low conductivity, nickelised or nickel-plated iron should be employed. The nickel surface has a conductivity a little above that of the mass of iron, and it is not in the least subject to oxidation. It is even proposed to nickelise the rod throughout, which would result in the following of the principle laid down by Franklin, 'that lightning-rods should be of only one metal.'—*Comptes Rendus de l'Académie des Sciences*, vol. lxxxi, p. 949.

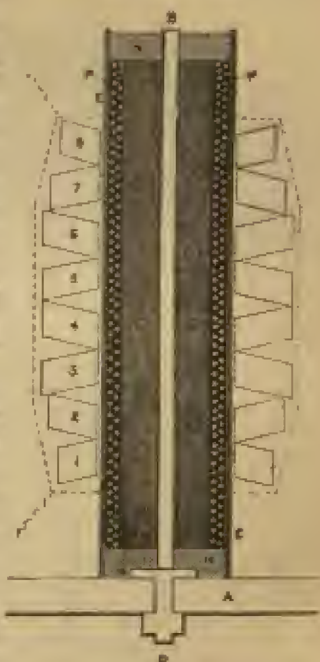
ELECTRIC INDUCTION COIL. An induction coil of a novel description, and in many respects remarkable for ingenuity, has been brought forward by Mr. G. F. BRUSH, a mechanical engineer of the United States.

A rod of iron about $\frac{3}{8}$ths of an inch in diameter, and nearly 14 in. long, B (*fig.* 2333), is held by a collar and nut, D, perpendicular to the supporting board, A. A couple of pieces of ebonite 2½ in. in diameter, N N, form the ends, and are fixed to the rod. The core, C C, is composed of iron wires well annealed, and made perfectly straight; from 1,000 to 1,500 may be employed.

This bundle of wires, when arranged vertically around the iron rod, is covered with four layers of paper saturated with paraffin. Upon this the primary coil, P, of copper wire, $\frac{1}{12}$th of an inch in thickness, is coiled; this should be about 90 ft. in length. When the first layer is wound on, it is covered with six thicknesses of paper, and then the second coil of copper wire is wound on, with a narrow strip of paper between the consecutive turns, a tube of ebonite, E, about $\frac{1}{8}$th of an inch thick, is slipped on, and the coil is ready for winding on the secondary. This is 30,000 ft. in length, and is wound in eight sections, as shown in the figure. The centre sections, 3, 4, 5, 6, contain 67 layers each; sections 2 and 7, 55 layers, and 1 and 8, 35 layers respectively. The consecutive layers in each section are insulated by paper saturated with wax, and the consecutive turns of the wire in each layer are wound with a space of about $\frac{1}{200}$th of an inch between them. The wedge-shaped spaces between the sections are filled in with paraffin, and between the secondary coil and the ebonite tube, E, is also a layer of paraffin. The whole of the outside is covered with similar material, as shown by the dotted line.

In winding this secondary coil, the outside layer (1) is wound first, and the winding proceeds until the requisite numbers of layers have been coiled, and the inner section (2) is reached, when the wire passes to section 2, the inside layer is first wound, and this being completed, section 3 is commenced with the outside layer, and so on throughout, as indicated in the figure, by the touching of the sections.

2333



Economy of space is claimed for this induction coil, as, it is said, the same length of silk-covered wire would occupy double the space required by this method.

A coil made as above described is said to have given, when worked by two BUNSEN cells, sparks of 3½ in. long. The condenser used with this coil is made of 200 sheets of tinfoil, 5 in. by 10 in., arranged on the usual plan, and separated by single sheets of varnished paper. Coils quite as powerful as this one have been made in this country with less wire; but the novelty in the arrangement of Mr. Bacon's gives it a claim to attention.

ELECTRIC LADDER. HUGHES's *Apparatus.* — Automatic telegraphic transmission possesses certain advantages. Besides the regularity and accuracy of the signals, the work-capacity of a wire is sensibly increased. As far back as 1861, an automatic arrangement was proposed for the HUGHES apparatus by M. RENOIR; but the system of M. GIRARDON possesses the advantage that it is easily adapted to the existing HUGHES apparatus, and can be as easily and momentarily replaced by the ordinary key transmission. The basis of the system is the automatic chain. This chain is in the form of a narrow ladder, of which the sides are two interlaced cords, coupled parallel by the rungs, which are flattened metallic rings. In each space between two rings, between the double lacets, slides a metallic traverse, which is prevented from quitting the chain by a central stop. All these traverses are of equal length, and each carries a letter, figure, or conventional signal. The composition of the despatches is effected by a dial-plate composer in which, by the depression of the lever on the dial corresponding to the required letter, the proper traverses in the chain are thrust forward. The chain thus composed or arranged is carried to the transmitting cylinder, where it controls the contacts of the transmitting lever in such a manner as to give the required number of contacts to actuate the type wheel, similarly as if the signal were sent by the key. (*Annales Télégraphiques*, 3rd ser., vol. iii. p. 490.)—*Abstract of Papers in Foreign Transactions* (*Institution of Civil Engineers*).

ELECTRIC LIGHT. Several very successful experiments have been of late made with electrical arrangements adjusted for the purpose of producing illuminating power. In this country, at the Teesdale Ironworks, Stockton, the Messrs. SIEMENS BROTHERS placed one of the electrical engines, which illuminated the workyard in a very remarkable manner. The machine required for generating the electric current was driven by a belt from the workshop shafting. One and a-half horse-power was required, and the illuminating effect was calculated to be equal to 1,200 candles. Similar experiments have been made at the works of the London and North-Western Railway at Crewe, and the Messrs. SIEMENS have illuminated a portion of their telegraph works at Woolwich by means of one of the dynamo-electric engines.

The vertical section of their induction coil, *fig.* 2334, will sufficiently explain the principle of the system employed. The light is produced by the rotation of a bundle of insulated copper wire in the usual manner. This wire is coiled in several lengths, and with many convolutions, upon a cylinder, *a b c d*, in such a manner that each single convolution describes the perimeter of the longitudinal section of the cylinder. The whole surface of the metal cylinder is thus covered with wires, forming also a cylinder closed on all sides. This hollow cylinder of wire encloses the stationary core of soft iron, N, S, S¹, N¹, which is made stationary inside the cylinder of wires by means

of an iron bar in the direction of its axis, prolonged at both ends through the bearings of the wire cylinder, and extending to the standards. Around the wire cylinder, and

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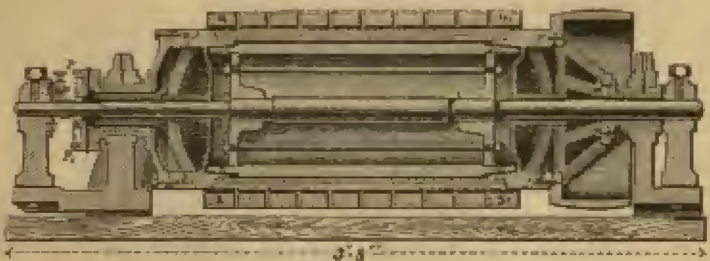

in close proximity to it, are curved iron bars, N, N', S, S', so arranged as to allow only enough space for the cylinder to revolve freely between them. These curved iron bars are prolongations of the cores of the electro-magnets; and the sides of these cores are connected by being screwed to the iron standards. A continuous circuit is formed by the coils of the electro-magnets, and the wires of the cylinder, which latter rotates in a feeble magnetic field formed by residual magnetism. In this way a current is excited in the wires of the cylindrical armature, passes into the magnet coils, and increases the intensity of the magnetic field, and of the current, which latter is collected on rings, r r', or metal brushes placed in communication with two terminals. From these terminals a continuous current is conveyed through leading wires, and the electric lamp, which may be placed at from 400 to 500 ft. from the dynamo-electric machine, without sensibly diminishing the intensity of the light; a longer distance even than this does not reduce the light if leading wires of sufficiently small conducting resistance be selected. At a speed of 1,200 revolutions per minute of the induction cylinder, a light, having an intensity of 15,000 candles, can be obtained with 6 horse-power.

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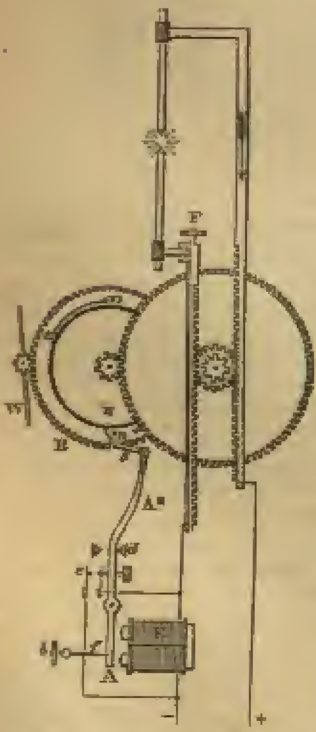

At page 204, vol. ii., a drawing of an electric lamp is given. It is the form adopted by M. Archereau, and was for many purposes an exceedingly useful arrangement. It appears, however, desirable that the lamp adopted by the Messrs. Siemens should be described.

The lamp is self-regulating, and is actuated without clock-work. This removes a source of failure and difficulty. The working parts of this lamp are shown at *fig.* 2335. By the united action of distancing and bringing together, the carbon points are automatically kept at a uniform distance apart, so that a perfectly steady light is obtained. The electro-magnet, E, has an armature, A, opposite its poles. A spiral spring, *f*, the tension of which can be regulated by the screw, *h*, withdraws the armature from the poles of the electro-magnet, and brings its prolongation, A', against the stop, *d*. When a current of sufficient strength to overcome the tension of the spring, *f*, circulates in the coils of the electro-magnet, the armature is attracted, thus establishing contact at *c*, which, offering a shorter route, diverts the current from the coils of the electro-magnet into the 'shunt,' as it is called. The consequent release of the armature from the poles of the electro-magnet reopens the contact at *c*; the armature is

again attracted, and this action is repeated during the use of the machine. When, therefore, the carbon points are so close that the resistance of the electric arc is sufficiently small to maintain a current in the coils just powerful enough to overcome the tension of the spring, *f*, the armature, A A[1], begins to oscillate, and continues to vibrate while the current remains of the same intensity. The spring pawl, *s*, at the extremity of the arm, A[1], oscillating with the arm, actuates a five-toothed ratchet-wheel, *u*, in gear, by means of a train of wheels and pinions, with the racks of the carbon holders; and resists and overcomes the gravitating tendency of the upper carbon holder, thus slowly parting or distancing the carbons. Increase of resistance follows this distancing of the carbons, and the current becomes proportionately weaker; the armature ceases to oscillate, and again rests upon the stop, *d*.

In this position the spring pawl, *s*, by its inclined face bearing against a pin, *n*, is released from the teeth of the ratchet-wheel, *u*; the preponderating weight of the upper carbon holder now comes into play, and the carbons are brought towards each other, the spur-pinion on the spindle of the ratchet-wheel, *u*, revolving in an opposite direction to that when under its influence. The speed at which the carbons approach each other is regulated by the fly, *w*, the driving wheel, *a*, of which turns loosely on the axis of the ratchet-wheel, being coupled to this wheel by the spring detent, *t*, the detent acting only when the carbons approach. When in action, the alternating movement of the carbon is scarcely perceptible; but when, owing to any exterior influence, the light is extinguished, the carbons immediately run together, ignite as soon as contact is established, and work apart, under the action of the electro-magnet, to the distance determined by the tension of the spring, *f*. The tension of this spring is the only matter requiring attention, when this is regulated and adapted to the strength of the current, the lamp will continue to throw a constant light so long as the current remains constant.

Dr. ANDREWS, F.R.S., in a lecture delivered by him in Ireland, says: 'I cannot pass over the machine of SIEMENS and ALTENECK, in which electrical currents are obtained solely by the rotation of a longitudinal helix of insulated wire. This helix revolves in an annular space bounded externally by two semi-cylindrical magnetic poles, and internally by a stationary cylinder of iron, which latter may also be an independent magnet. The following account of this apparatus I give nearly in the words of the inventors. Between the poles of one or more magnets or electro-magnets an iron core or cylinder is placed, so as to leave a space between it, and the faces of the magnetic poles, which have a cylindrical form, and are concentric with the iron cylinder. In this annular space a cylindrical shell of light metal is made to revolve, on which a coil of insulated wire is wound parallel to the axis of the shell, and crossing its ends from one side to the other. There may be several such coils, each covering an arc of the periphery of the shell. The ends of these wires are connected by metallic rollers or brushes with two stationary conductors, which are insulated, and constitute the poles of the machine. The currents obtained on rotating the shell may be made, either continuous or intermittent, or they may be alternately reversed.'

GRAMME's *Electric Engine*.—The GRAMME machine now in use for the production of the electric light is a considerable improvement on the machine which was tried on the clock tower of Westminster Palace. That machine had the defect of becoming heated while at work, and of giving sparks between the metallic bundles of copper wire and the conductors from the helices. The entire machine weighed 700 kilogrammes, and there are 180 kilogrammes of copper in the electro-magnets, and 10 kilogrammes in the two rings. It produced a normal light of 500 CARCEL burners; but, by augmenting the velocity, it was asserted that the amount of light could be doubled.

In *fig.* 2336 we have the latest improvements devised by M. GRAMME for producing the electric light. In this machine there are only two bar electro-magnets and a single moveable ring placed between the electro-magnets. Its weight is 183 kilogrammes, and the entire weight of copper used in its construction, both for the ring and for the electro-magnets, amounts to 47 kilogrammes. Its normal power is about 200 CARCEL burners, but this can be greatly augmented by increasing the velocity. It may be interesting to give the results of some experiments with this machine.

Number of Turns	CARCEL Burners	Remarks
450	77	No heating or sparks
830	125	" "
880	150	" "
900	200	" "
935	250	Slight heating, no sparks
1025	300	Heating and sparks

By uniting two or more machines together, electrical currents of high tension may be obtained. But a more useful arrangement is to divide into two, each ring, so that the two halves may be joined either for quantity or tension, and varied effects thus ob-

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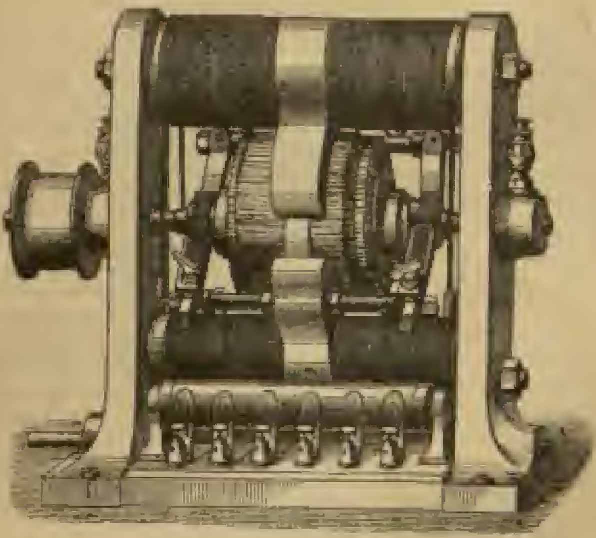

tained from the same machine. This is effected in the following manner. Suppose the machine to contain sixty bobbins or helices round the ring. If the entrance of the thirty alternate bobbins is placed on one side of the ring and of the thirty other bobbins on the other side, there will be in reality two ring-armatures in one, interlaced as it were into each other; and by collecting the currents by means of two systems of rubbers, one to the right and the other to the left of the ring, we may obtain from each, one half of the electricity produced by the rotation of the ring. By applying this principle to machines for producing the electric light, the same machine may give two distinct lights instead of one. In its industrial applications, this is a point of capital importance. The use of the electric light is at present greatly interfered with by its excessive brightness, and the deep shadows which by contrast are produced at the same time. These defects will be to a large extent remedied by the use of two lights, so that the shadow from one may be illuminated by the other. It is proposed to use four electric lights, each of the strength of fifty CARCEL burners, for lighting foundries and large workshops. In support of this proposal it may be remarked that DUBOSCQ's lamp of the latest construction gives a singularly steady and mild light, with only twenty BUNSEN's cells, and would of course work equally well with currents of the same intensity from a magneto-electric machine.

In 1871 M. JAMIN communicated to the French Academy of Sciences a short note by M. GRAMME, on a magneto-electric machine, which gave electrical currents always in the same direction by the revolution of an electro-magnetic ring between the poles of a permanent magnet. The construction of the electro-magnetic or ring armature in GRAMME's machine differs in some mechanical details from the transversal electro-magnet of PACINOTTI, which it has indeed entirely superseded.

In its simplest form this armature consists of a ring of soft iron round which is wound a single closed coil of copper wire or other metallic riband covered with silk, except at a single point in each loop of the coil. In *fig.* 2337 such a ring is shown, placed between the poles of a permanent magnet. The parts of this ring contiguous to the poles, N S, of the fixed magnet will acquire, respectively, polarity of the opposite kind to that of the neighbouring pole, while the parts of the ring, o o', at the end of the diameter at right angles to the line joining the poles will be neutral.

To make the explanations clearer, let us suppose that there is only one loop of wire, *s*, *fig.* 2338, upon the ring, and that this loop is moveable, and in connection with a

galvanometer, *g*. If now the loop is moved along the ring (assumed to be at rest) from the neutral line *o* towards *s'*, a current will be developed in a certain direction, the intensity of which will increase till the loop reaches *s'*, after which the current, always preserving the same direction, will diminish till the loop arrives at *o'*, when the current will, for a moment, fall to zero, to be succeeded by a current in the opposite direction as the loop leaves *o'*. This current will in like manner increase during the advance of the loop to *s'*, when it will attain a maximum, and afterwards diminish till it arrives at *o*, where, after passing through zero, the direction will again change. There will thus be a current always flowing in one direction as the loop moves from *o* through *s'* to *o'*, and in an opposite direction as it moves from *o'* through *s'* to *o*. Now if the loop, instead of the fixed magnet, N M S, be moved, it will be found that the currents developed will correspond, both in direction and intensity, with those produced in the moveable loop, provided we allow for the small displacement in the position of the poles of the ring arising from its motion.

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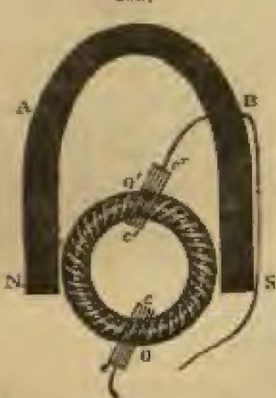

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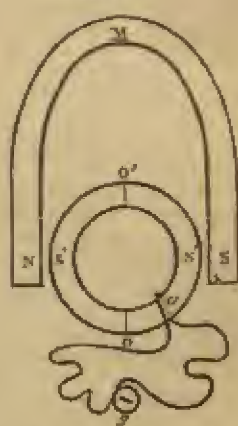


The foregoing statement may be extended from a single loop to any number of loops forming part of a coil extending over the whole of the iron ring, *fig*. 2337.

The machine may be converted into an electro-magnetic one by transmitting the current from a voltaic pile through the helices of the iron ring, which will then rotate on its axis. If the current be supplied by another magneto-electric machine, the same result will be produced, and we shall thus have mechanical force, after assuming the form of current electricity, reappearing, but with some loss, in the form of mechanical force. In an experiment on the large scale described by M. Breguet, the loss amounted only to 50 per cent. If during this experiment the machine which supplies the current has its motion reversed, the other machine will soon come to rest, and afterwards begin to turn in the opposite direction. The intensity of the current, M. Breguet remarks, augments with the velocity of the rotation, the electro-motive force having been proved by experiment to be proportional to the velocity. At first view it might appear that the resistance would remain constant; but as the intensity is found not to be proportional to the velocity of an invariable circuit, we are led to the conclusion that the resistance of the machine is not constant. This important point has been established by M. Sabine, but the details of his experiments have not been published. The increase of resistance is, however, so small, that a machine which gives with a velocity of 100 turns per minute a current equal to that of one small Bunsen's element will give with a double velocity a current equal to two such elements a little larger, and with a quadruple velocity a current equal to four still larger elements of Bunsen. It is certain that this increase of electromotive force cannot be indefinite, but must tend towards a limit; but this limit does not appear to have been reached even with a velocity of 3,000 turns per minute.

From this property of the Gramme machine it may be employed to measure, by the method of opposing currents, any electromotive force. For this purpose it is only necessary to ascertain the velocity of rotation of the ring when the equilibrium between the currents is established. This may be measured in one of two ways—by the velocimeter of Deschiens, or by a chronoscopic diapason. The mode of operating with the latter when applied to the Gramme machine is thus described in M. Breguet's

work. 'On the axis of the ring is mounted a small plate whose plane surface is covered with lamp-black by holding it over a candle. A tuning-fork vibrating 100 times in a second, and carrying at one end a little style, is held in the hand, or, still better, fixed on a special support. At the precise moment that the two electromotive forces are shown by the galvanometer to be equal, the style is brought into contact with the blackened surface of the plate, upon which it traces a sinuous line. A very short contact is sufficient to give the required result. On stopping the machine, it will be seen to what fraction of the circumference ten sinuosities of the line traced on the plate correspond, from which it may be inferred in how many hundredths of a second the entire revolution of the ring has been accomplished. It is stated that if the ring in the GRAMME machine be turned at a perfectly steady rate, the current produced will be more rigorously constant even than that of a DANIELLS battery in good working order.'

In a communication to the *Académie des Sciences*, M. TRESCA has given an account of a series of experiments which he had instituted for the purpose of determining the work performed by the magneto-electric machines of M. GRAMME, used to produce light by electricity. His experiments had reference to two machines emitting light equivalent in brilliancy to 1,850 and 300 (carcel) candles respectively.

Authorised by the COMPAGNIE DU NORD to make a series of similar experiments with the aid of MM. SARTIAUX and ROUTHSON, standard machines of 50, 100, and 150 candle power, respectively, were selected for the purpose.

'Repeated experiments have been made in the freight depôt having an area of 1,500 square mètres (16,146 sq. ft.), and a capacity of about 19,000 cubic mètres (671,023 cub. ft.), as well as in the large market whose area is 11,000 square mètres (118,404 sq. ft.), and 300,000 cubic mètres (10,595,100 cub. ft.) in volume.

'The power necessary to set magneto-electric machines in motion was ascertained by a comparison with engines driven by gas or vapour, of 2, 3, or 4 horse-power, used either separately or coupled. Previous determinations, however, with a PRONY dynamometer had given the relative volume of gas consumed to the power derived (i.e. useful work), all the conditions remaining the same.

'The lamps which were used in the experiment, were regulators of the V. SERRIN type, and the purpose remarkably well.

'The following results were obtained:—

	Magneto-electric machine of		
	50 candle power	100 candle power	150 candle power
Number of revolutions of the bobbin per minute	1650	800	800
Power necessary to secure a steady light—			
With carbons 0·007 m. apart	2·2 ch.	2·4 ch.	2·5 ch.
Ditto 0·009 m. apart	..	2·6 ch.	2·7 ch.
Consumption of carbons of the lamp, including waste—			
With carbons 0·007 m. apart at positive pole	..	0·090 m.	0·136 m.
Ditto at negative pole	..	0·045 m.	
With carbons 0·009 m. apart at positive pole	..	0·060 m.	0·090 m.
Ditto at negative pole	..	0·030 m.	

Thus it has been indicated by M. TRESCA that these results show that the power necessary to produce a certain amount of electric light—for instance, that equivalent to 100 candles—increases very rapidly in proportion to the diminution of the total quantity of light; whence M. TRESCA has proved that the work per 100 candles was only 0·415 ch. for a lamp of 1,850 candles, that it was 0·020 ch. for 100 candles with a lamp of 300 candles, whilst the work per hundred candles amounts to 1·7 ch., 2·4 ch., and 4·4 ch., for machines of 150, 100, and 50 candles respectively, with the carbon points seven millimètres apart.

The experiments have furthermore shown that the requisite power to obtain the formation of the voltaic luminous arc is about 10 per cent. greater than that which

burns at the uniform rate. This is true at the starting of the machine when the carbon points are in close contact and the resistance to the passage of the current only feeble; when, by and by, the electricity developed is transformed into magnetism in the electro-magnet and revolving band of the GRAMME machine, and these then act successively, in forming a kind of brake which continually charges the motor.

The experiments have shown that the power given out by magneto-electric machines varies with the sizes of the carbons of the lamp, a little more power being requisite for 0·009 m. than for 0·007 m. carbons. This again is due to the smaller resistance offered by the 0·007 m. carbons to the passage of the electric current, producing the effects of a brake as mentioned above.

The power varies but little in machines of 50, 100, and 150 candle-power, and, consequently, the rates of production of all the light from these different machines are sufficiently close. Excluding exceptionally rare cases, it will be advantageous to employ machines of 100 and 150 candle-power.

It has been seen that the consumption of the carbons of the electric lamp was 0·135 m. and 0·090 m., when the carbons were used at distances of 0·007 m. and 0·009 m. apart. From this time forward the COMPAGNIE DU NORD is warranted in paying for carbons of coke, and even for those of M. CARRÉ, which are perfectly regular, at the rate of 1 fr. per current mètre; whence the figure, representing the cost per hour, may be set down at 0·135 fr. and 0·090 fr.

The following figures are interesting, in so far as they give the comparative expenses incurred in the use of electricity and gas as means of illumination. Taking, for example, the lamp of 150 candles and allowing it to emit light for ten consecutive hours in some spacious hall or railroad depôt, 150 CARCEL candles will require a consumption of 150 × 0·15 mc. of gas per hour, equal to 15·75 m., which, at the rate of 0·36 fr. per cubic mètre, would constitute an expense of 5·70 fr.

In using electricity for illumination, 150 CARCEL candles require 2·7 ch., which, at the rate of 0·09 per horse-power per hour (including cleaning and lubrication) the expense would amount to 0·24 fr.; adding to this, 0·09 fr. for the carbons of the lamp, 0·45 fr. for wages to the employé, and 0·20 fr. for the interest and liquidation of the expense of instalment, the total amount would be 0·98 fr., or, in other words, between the one-fiftieth and one-sixtieth part of the expense involved when using gas for illumination.—*Comptes Rendus de l'Académie des Sciences*, vol. lxxxii.

Numerous attempts to employ electricity for illuminating purposes, with economy, have been made. M. LODYGIN has received from the St. Petersburg Academy of Sciences the LOMONOSSOV prize awarded to inventors, for his electrical light. It is well known that, under the influence of a strong electric current, a body which is a good conductor, when connecting the two poles of the current, may be heated to such a point as to become luminous. This phenomenon is turned to account by M. LODYGIN for obtaining a constant light, which is both reasonable in cost and capable of being used under all circumstances. Instead of producing the electric light by the wearing away of the electrodes—that is to say, by the ignition of the particles of charcoal which are transported from one pole to the other in a body of air heated to a high degree between the electrodes—M. LODYGIN employs a short stick of charcoal in a single piece, and reduces the area of its section between the two electrodes in such a manner that it offers considerable resistance to the current; so that the portion between the two poles, being heated to a high degree, becomes luminous just as a metallic wire would do. The lamp consists of a cylindrical glass vessel closed with metal covers, so as to be air-tight both at top and bottom. Occupying the centre of this cylinder is the stick of charcoal held in its place by two pieces of metal communicating, through the covers, with the two electrodes of the battery. In order to render the light more intense, several sticks of charcoal may be placed in the same lamp; the conducting wire which leads the electricity from the battery communicates with an insulated rod connected with the cover and in contact with the first piece of charcoal; the electric current then passes into the second piece of charcoal through the lower cover, and from thence to the next lamp, or to the battery. On account of the heating of that part of the charcoal which is reduced in thickness, the surface rapidly becomes oxidised when in contact with the oxygen of the air, and the charcoal is consequently worn away—a circumstance which would tend to considerably limit the duration of the lamp. To avoid this drawback, however, the lamp is filled with nitrogen, which is prevented from escaping by the two air-tight covers; in this manner oxidation cannot take place, and the pieces of charcoal preserve their original dimensions. This result has led, it would appear, to the very ingenious arrangement invented by M. JABLOCHKOFF, of Russia, which must now be described.

Jablochkoff's Patent Electric Lamp has been creating a large amount of attention,

mainly from its introducing a new method for securing the permanency of the electric light. In his specification he says:

'This invention consists of the entire removal of all the mechanism generally used inside electric lamps. Instead of causing the carbon points to approach each other automatically, by means of machinery in proportion as they are consumed, they are placed side by side as shown in the drawing (*fig.* 2339), and an insulating substance is placed between them, which consumes at the same rate as the carbon points—for instance, porcelain, brick, magnesia, or any other insulating substance.

'The carbon used may be—

'1st. The ordinary carbon points used for the purposes of electric lights.

'2nd. Hollow carbons of different sizes to admit of one being placed inside the other, or.

'3rd. Carbons made of compressed coal, which are well suited to the tube arrangement before mentioned.

'The two carbons thus prepared are fixed in a stand which may be described as a special candlestick, and a current of electricity by means of a battery or any other source is passed through them.

'To light the lamp the tops of the carbons are joined by a small piece of carbon, which, on the electric current passing through, produces light.

'To prevent one of the carbons consuming more rapidly than the other, carbons of different thicknesses are used to ensure equal consumption of both.

'Between the two carbon points a piece of the insulating substance is placed, or one or both of the carbon points are placed in an insulating tube or tubes.

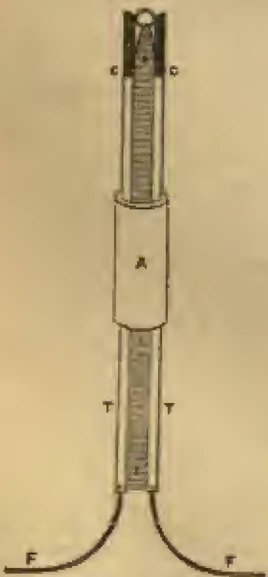
'The drawing (*fig.* 2339) represents the carbons as parallel to one another, but they may be fixed inclining to one another.

'Having thus described the nature of this invention, and in what manner the same is to be carried into effect, M. JABLOCHKOFF claims:

'1st. The mode of placing the carbons side by side with an insulating substance between them for the purpose of producing light by passing an electric current through them.

'2nd. The application of this electric light so produced for lighting purposes generally, both on land and sea, and for submarine purposes.

2339



'3rd. The right of producing a coloured light by mixing colouring matter with the isolating substance which separates the carbons.

'(Signed)

'ROBERT APPLEGARTH, *the English Patentee.*

'Sept. 11, 1876.'

(No. 57 Patent, 3552, 1876.)

A more complete description of the most recent arrangement of this electric candle will be found in the following quotation from the *Electrical Journal*:—

'In the adjoining figure (2339), C C, are the carbons placed parallel, with insulating matter, I I, between them (a plate of glass, kaolin, or the like); T T are tubes of copper, in which the carbons are held; A is a case of asbestos; F F are the copper wires conveying the electric current. The voltaic arc is formed between the points of the carbons.

'It might be supposed that the insulating plate while separating the carbons would ere long break and extinguish the voltaic arc by forcing it to elongate too much. But it is not so. The high temperature of the voltaic arc suffices to fuse and even vaporise the glass or kaolin, so that this is used up in the same time as the carbons.

'If continuous currents be used the consumption of the carbons will be unequal, and the distance may become so great between the points that the light is extinguished. This difficulty is met by giving a double section to that carbon which is used up most quickly. But the electric candle has hitherto acted better with magneto-electric machines, giving alternating currents, than with batteries or GRAMME machines. In this case the carbons are consumed equally and may have

the same action. One interesting peculiarity of the candle is that the light may be put downwards, so that no part gives a shadow, and it shines on the ceiling like a star in the sky. Its brightness may be softened with diffused glasses, as with electric lights or gas.

'One of the chief advantages of the candle is that it can be lit at a distance. M. JABLOCHKOFF has solved this difficulty in a very simple way. He places between the two carbons a small piece of pencil-lead, which establishes continuity. When the current is sent, this little ball is heated, reddened, and soon consumed. The voltaic arc is then formed. Instead of the pencil lead a fine metallic wire may be used or a piece of metallic lead.

'Again, the matter between the carbons, which insulates while solid, becomes conductive in the liquid state and permits an elongation of the voltaic arc beyond what could be obtained in free air. This conductivity allows of opening the circuit momentarily and relighting the candle without any of the artifices for relighting just indicated. Beyond a certain time the cooling suppresses the conductivity and relighting is impossible. The arc may be extinguished during nearly two seconds, and lit by merely closing the circuit again. This particularly makes the electric candle suitable for the transmission of telegraph signals by the MORSE alphabet. A series of short or long flashes are produced, separated by eclipses of varying length. The candle is more suitable for this than the lamp, because its relighting is quicker and more immediately complete. Indeed, the lamps come to give the voltaic arc in its normal length only gradually, whereas in the candle it has always a length superior to the thickness of the insulating plate. In optical telegraphy, hitherto, the MORSE alphabet has also been given by flashes and eclipses; but these changes have been worked by means of screens brought before the light and withdrawn. Such mechanism is unnecessary with the JABLOCHKOFF candle.

'With the candle—provided the source have sufficient tension—several voltaic arcs may be placed in the same circuit instead of a single light.'

The practical solution of the question of the use of the electric light for industrial purposes is thought to have been made with the GRAMME machine, applied to a SERRIN lamp. As light-unit, the CARCEL burner or lamp was adopted, which, consuming 23·68 drams of refined oil per hour, with a flame of 1·38 inch, gives a light equal to that of seven stearine candles, each burning 5·04 drams per hour. It was found that the motor-force required to drive the machine did not in any case exceed 1 kilogrammètre per second for each light-unit produced. The carbon points cost at the present time 4½d. per foot, whatever the section, but this expense would probably diminish under other circumstances of production. Four magneto-machines of 100 CARCEL standard light-power each, worked by a portion of the force of a powerful motor, would not consume more than 4·4 lb. per HP. per hour of fuel. This for 400 kilogrammètres per second, or 5⅓ HP., corresponds to 24·2 lbs. of coal. Thus an electric light equivalent to 400 CARCEL burners would consume per hour 12·6 in. of carbon at 4½d. per foot, and 24·2 lbs. of coal at about 0·13d. per lb. or a total of 8·13d. For the same light with gas the cost would be that of 1,465 cubic ft., at 6s. 8d. a thousand, or 10s., being in the ratio of 1 : 14 as the relative cost of electric light and of gaslight. Allowing about 1,000 hours' use per annum, interest upon capital invested in the machines would raise the cost of the light by another franc per hour; and if motor-force were not in existence this would be still further increased by increased special consumption of fuel, and interest upon capital to from 26·6d. to 30·4d. the hour, decreasing the ratio to 1 : 4. Using illuminating gas, as a motor in an OTTO and LANGEN gas-engine, the ratio would fall to 1 : 3, which is the most unfavourable case considered. M. H. FONTAINE gives the expense and detail of cost actually incurred by several works using the electric light, varying from 2s. 4½d. per hour for a 400-power light (which need not, it appears, radiate from only one lamp, but may be dispersed from several lamps at different parts of the works), including all expenses and interest, to 6·8d. per hour for a 300-power light in one case, where the motive power is partly derived from a turbine.'—H. FONTAINE, *Revue Industrielle*, vol. vii.

The *Comptes Rendus* publishes the following abstract of a paper presented to the *Académie des Sciences* by MM. DENAYROUZE and JABLOCHKOFF.

Divisibility of Electric Light. Of this M. DENAYROUZE says:—

'Although the invention of M. PAUL JABLOCHKOFF has been in continual progress since the first communication that I had the honour of making to the Academy, I thought it better to wait, before again calling attention to our studies, until a decisive application had been shown publicly and practically.

'1st. The regulator can be advantageously replaced by a "candle."

'2nd. It is possible by this process to obtain several luminous foci with a single electric current.

'We put these two points beyond discussion by lighting one of the principal halls of the Louvre, every evening, with the multiplied foci.

'After this public verification of the principle submitted to the Academy, I think I can announce another new and important result obtained by M. JABLOCHKOFF during several months of study and pursuit in the workshops of the society that I direct.

'In the first trials made with the "candle" we have discovered that if we obtain a more continuous light than with the regulator, and if at the same time several luminous points are produced, this double result is due to the action of the current on the insulating matter interposed between the two charcoal points. The voltaic arc, in putting this substance in a state of fusion, establishes, for the current between the two charcoal points, a sort of passage much more easy than when the insulator was in a solid state. Experience shows that in giving a certain tension to the current of the machine the distance that this current can travel, on this sort of liquid conductor, is considerable enough to create a number of luminous points. It is thus that we obtain lights equal to 8 wax candles from the circuit of a single machine of the most ordinary type.

'Since then, M. JABLOCHKOFF has been induced to try the effect of sparks produced by a strong current on the refracting body.

'He has introduced in the central circuit of the machine, the inside wire from a series of induction bobbins, and made the spark arising from the induced current pass on to a layer of *kaolin* placed simply between the two extremities of the outside wire of each bobbin.

'Having found, then, that the current was not sufficiently strong to put the interposed kaolin in a state of fusion, it was heated to the point of incandescence.

'The current is then passed on a better conductor, arranged on the edge of the plate of kaolin. The part of the plate which is warmed in this manner then gives a line which becomes a very resistant conductor, and on the passage of a strong current becomes white-hot and emits a beautiful light. There is a certain consumption of kaolin along the whole length, but this consumption is very little. The plate of kaolin submitted to the action of the current is reduced, on the lighted part, about 1 millimètre an hour.

'The result thus obtained, between the two extremities of the wire of the bobbin, is a magnificent band of light, which can attain a much greater length than the ordinary induction spark produced by the bobbin that is generally employed. This luminous band, instead of being not so bright as the induction spark, is a permanent focus, giving a light as soft and more steady than any known light, not only electric, but any in common use. As to its power, that only depends on the number of spires and the diameter of the wires of the bobbins employed.

'As a great number of bobbins can be placed in the circuit, and as each bobbin can be divided into several sections, each lighting a band of kaolin of convenient length, we arrive at a complete divisibility of the electric light. We can very easily obtain 50 luminous points of variable intensity.

'In our experiments we have employed bobbins of different sizes. The intensity of the light varies naturally with the dimension of the bobbin. In our experiments we have made a scale of the intensities of the different luminous points, so as to have a graduated series of luminous bands, of which the weakest gives a light equal to 1 or 2 gas burners, and the strongest to 15.

'In employing the alternate currents, the interruptor and the condensator can be suppressed, then the total system of distribution of currents is reduced to a central artery, represented by the series of inside wires of the bobbin, from which branch as many distinct conductors as there are bobbins on the circuit. Each luminous point is then perfectly independent, and each one can be extinguished or lighted separately. The distribution of electricity in lighting a building becomes analogous to the distribution of gas, and in the special work that we construct, great spaces would be lighted by the "candles," the offices and corridors by the luminous bands.

'The means for lighting small places are of striking simplicity. It reduces itself, indeed, to a simple plate, with a thin slab of porcelain, which will burn all night if it be about 1 centimètre long.'

Camacho's electric battery, which has been introduced with a view to its employment in connection with the electric light, appears to possess many very important advantages.

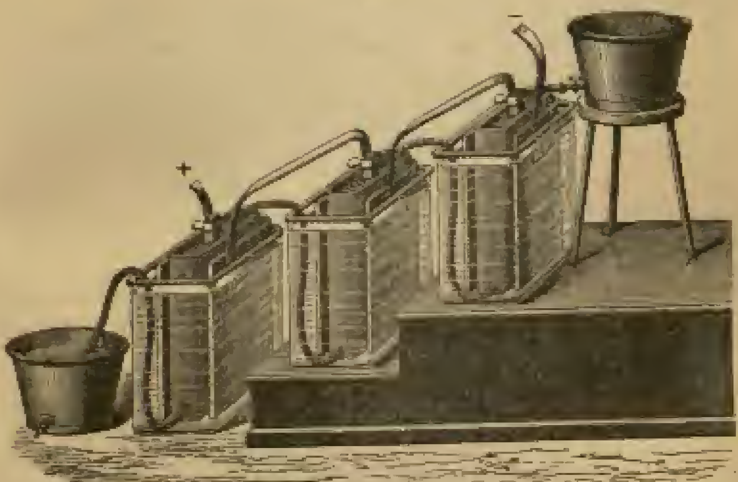
CAMACHO'S invention has for its object the rendering of the bichromate of potass battery constant in its action, and thus producing a powerful and continuous current for a long period of time at less than half the cost of any of the standard batteries. There have already been many attempts to accomplish this by agitating the liquid, and alternately raising and lowering the plates in the solution, &c.;

but in each case the result is only a temporary improvement, the battery giving good results for a few minutes after each agitation, and then relapsing into its former condition.

The cause of the intermittent action or sudden polarisation of this battery is the rapid deposition, upon the negative plate, of the residues resulting from the decomposition of the bichromate solution, and the agitation above referred to is for the purpose of preventing this residue from adhering to the surface of the plates.

In CAMACHO's arrangement (*fig.* 2340), a very large porous cell is used to contain the carbon element and bichromate solution, and the whole of the cell is packed full of small pieces of broken carbon with a square block of carbon in the centre, which thus forms the nucleus of a negative element having an enormous surface in contact with the solution. A very small quantity of the latter is necessary to fill up the interstices between the pieces of carbon, the supply of liquid with which the battery is actually charged being contained in a separate vessel, and kept continually circulating through and between the small pieces of carbon, passing from cell to cell through a series of from 4 to 6 cells and being finally received by another vessel from which the first or supply vessel is again replenished.

2340



The principal advantages are summarised as follows:—1st. Constancy in action, with a current of great power and intensity. 2nd. Absence of fumes. 3rd. Facility in manipulation, the changing of liquids being effected and the battery re-charged without removing the connections. 4th. Cheapness in action, the cost of working being little more than one-third that of a BUNSEN's battery of same power.

The comparative working value of the BUNSEN's battery and CAMACHO's arrangement are best illustrated by the following abstract figures:—

Bunsen.

Electromotive force	11·123
Interior resistance	·154

Camacho.

Electromotive force	12·912
Interior resistance	·320

It will thus be seen that the electromotive force, and consequently the tension, is in excess of BUNSEN's; but the interior resistance being double, of course each element requires to have double the surface to give the same result in *quantity*.

The comparative working cost is as follows:—

Cost per hour of one cell in francs.

Bunsen.

	Francs
Zinc	0·0127
Sulph. acid	0·0044
Nitric acid	0·0243
Total	0·0414

Camacho.

	Francs
Zinc	0·0127
Sulph. acid	0·0028
Bichromate potass	0·0050
Total	0·0205

The battery, if worked through a local circuit with but nominal resistance, will remain in constant action for 20 hours; at the end of which time the acid in the exterior cell will become exhausted, and for the first 10 or 12 hours the current will be of uniform intensity. M. CAMACHO is also the inventor and patentee of a new electro-magnetic engine, in which the armatures are formed of metallic plates insulated from one another, and he has introduced a new commutator of an ingenious description. We have not, however, any information as to the first cost of this engine, or of the cost of working it.

Leclanché's Cell.—The coke manganese galvanic cell is fairly well known, as giving a very constant current, but which, however, is much decreased by the resistance of the tar covering the top of the porous cell, and by the decomposition of the manganese dioxide, which is transformed during the action of the cell into manganous oxide; the latter oxide closes the pores of the cell. Mr. SERGIUS KERN, of St. Petersburg, states that his battery is a modification of LECLANCHÉ's one, and that experiments have proved it to act very constantly. Two parts of cleanly washed coke, and one part of manganese dioxide (MnO^2) in the state of powder are well mixed together with a small quantity of water acidulated with some drops of nitric acid; the mixture then is strongly pressed into brown paper cartridges 0·125 metre high and 0·03 metre in diameter. The resulting coke manganese cylinders are dried in a warm place, but not over a fire, because the heat, as it is known, decomposes the manganese dioxide.

The dried cylinders are placed in glass jars containing concentrated solution of ammonium chloride (NH^3HCl), and surrounded by zinc plates curved in the usual manner. By this arrangement the use of porous cells is avoided, and a battery of such elements acts more constantly; besides this, the construction of it is cheaper. Instead of having glass jars, I am using wooden boxes, the size of the glass jars; the internal parts of the boxes are covered with the following mixture, melted in an iron cup:—2 parts of wax, 10 parts of common resin (colophony), 2 parts of red lead, and ½ part of gypsum.

The zinc of the element is the negative pole; the coke, the positive pole. The reactions which take place in this element may be represented by the following equations:—

$$2NH^3HCl + 2Zn = 2ZnCl^2 + 2NH^3 + H^2;$$

$$H^2 + MnO^2 = MnO + H^2O.$$

Chemical News.

ELECTRO-TELEGRAPHY, MUSICAL. (Vol. i. p. 220.) In 1870 M. BOURBOUZE instituted a series of experiments which went to prove the possibility of telegraphing between two stations without the use of connecting wires. The difficulties which were in the way were found to be numerous, but after having been laid aside for some years, M. BOURBOUZE has resumed the enquiry, encouraged by the facilities which LA COUR's musical telegraph affords for distinguishing between different messages.

In a recent number of *La Nature*, M. BONTEMPS gives a brief description of the apparatus which it is proposed to employ for transmitting messages by a system of musical notes, and introduces the subject with the following explanation of the principles of his musical telegraph:—

When the most common phenomena of acoustics are recalled—for example, the transmission of a melody played by an orchestra which is audible to an entire audience at long distances from the players, as introduced some years since by the late Sir Charles Wheatstone, and shown by him at King's College—it is not easy to

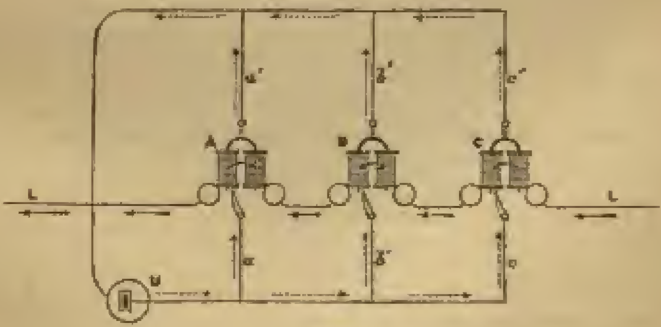
analyse the effect, although we explain it by saying that the vibrations, established at one end of the system, whatever it may be, are transmitted by a continuance of the undulations to its other extremity. Physics tell us that the sounds produced by each instrument have their own tonality and their distinct measure, that the notes from a violin, a flute, or a trombone, correspond to different vibrations, transmitted through the atmosphere and characteristic for each note. Thus the rhythm in the succession of notes, which makes the measure in music, produces the cadence, constituting, with the tonality and the timbre of the instruments, the *ensemble* of the air which affects us. The transmission is so precise that the ear, from the medley of sounds, instantly distinguishes a discordant or untimely note.

Suppose a series of three tuning forks, vibrating continuously and producing, respectively, 100, 300, and 500 vibrations per second. It is easy to perceive that each fork may interrupt and establish an electric current with intermissions regulated by the number of its vibrations. If, then, there be three other forks identical with the first, each set being located at an extremity of the conductor between them, the trio at one end will affect those at the other; and further, if one fork be impressed with a cadence which does not coincide with its regular vibrations, then its corresponding fork will likewise emit the same discordant sounds.

The details of the arrangement which has lately been exciting much attention and curiosity, are stated to be as follows:—

(1) It is necessary to construct a tuning-fork whose movements can be maintained by an electric current. (This problem has been solved by M. Marcel Deprez, and Mr. Gray of Chicago.) (2) It is necessary that these forks emit currents whose phases correspond exactly with their movement. (3) Finally, we must be able, in a very small interval of time—say one second—to arrest and put in action a great number of times (100 at least) each of these forks. This last point is the only one which presents any difficulty. The success of M. Marcel Deprez enables us to think that the third condition may be realised.

2341



2342

Fig. 2341 represents the device for transmitting the vibrations of the fork to the conductor. The arm, *n*, of the fork, *n n*, vibrates in contact with the platinum tongue, c, the position of which is regulated by the screw, c. A current entering at B is closed, when the extremity, *n*, touches the plate, c, and is open when contact is broken. Nothing further is needed than the opposite wire, L, connected with the fork as shown.

Fig. 2342 shows how the character of an intermittent current is recognised. L L is the main line traversing the station. A B C are three forks similar to those at the point of transmission. The fork, B, for example, which is in unison with the current, will be thrown into vibration, while the rest will remain silent. This fork, B, will then touch the platinum plate, c, *fig.* 2341, and will establish in the circuit $b b^1$ a local current of the battery, U, the poles of which are respectively applied at $a b c$ and $a^1 b^1 c^1$. The

local current will likewise be intermittent, according to the measure of the fork, but by reason of the velocity of the pulsations it will manifest itself in many cases as a constant current, either by operating a chemical decomposition, or by deviating a magnetised needle, or by exciting an electro-magnet. See TELEPHONE.

Transmission of Electricity.—Some very ingenious experimental investigations on the velocity of transmission of electricity in suspended wires, have been made by M. W. SIEMENS.

The method employed by him differs in some essential points from the plan conceived by him in 1846, for the measurement of the velocity of electricity. The earlier method required two steel rotating cylinders, equal in size and insulated from each other and from earth, as well as two pairs of lines, of which one pair connected the two cylinders, and the other pair two insulated conducting points placed opposite the peripheries of the cylinders. A Leyden jar is inserted between one point and the line connected to it, so that the discharge current must pass through the whole line circuit and leave a spark-mark upon the surface of each of the two cylinders. The difference in distance of the marks produced when the cylinder rotates, from that when the cylinder is at rest, constituted a measure of the time which the electricity required for traversing half the circuit. Considerable difficulties are presented in the preparation of this method. One of these consists in procuring four lines departing from the same place, of equal length, and sufficiently well insulated. But the principal difficulty is the mechanical one of making two steel cylinders insulated from one another and the earth, and so light and perfectly centred as to admit of the velocity of 100 to 150 revolutions per second. The following method was therefore designed. It consists in the employment of two Leyden jars or condensers, the inner coatings of which are connected to a point placed close to the rotating cylinder (itself connected to earth), one direct through a short wire, the other through a long wire circuit. The outer insulated coatings are metallically connected. If these are connected to earth, the electricity of the inner coatings of both jars will then be freed at the same instant, and be discharged through the point and the rotating cylinder to earth. If the rotation is sufficiently rapid, and the line of sufficient length, two widely separated marks will be produced upon the cylinder, their distance apart being the measure of the time which the electricity requires for passing through the line from the jar to earth. In the experiments this arrangement was modified so that two points, instead of one point, were placed opposite the cylinder and connected, one direct to one jar and the other through the line to the other jar. The points were as near as possible to one another, so that the synchronous marks produced by both on the cylinder while at rest lay close together and practically in one plane parallel to the axis. First a discharge of the jars is taken when the cylinder is at rest, and after that the discharge which serves for the measurement while the cylinder rotates. The cylinder is as light as possible, worked from a solid steel one with a diameter of 1·575 inch (40 millimètres) and 0·394 inch (10 millimètres) length. Its steel axis is furnished with a screw thread in connection with a powerful train of wheel-work by which constant velocity is maintained. The balance-wheel with one hundred teeth carries a small projection which strikes a bell; when the governor is so arranged that the stroke of the bell occurs at the same time as the tick of a seconds pendulum, then the cylinder revolves exactly one hundred times per second. Attached to the apparatus is a microscope for reading off the spark-marks. One millionth of a second can be read off, and one ten-millionth estimated.

Instead of Leyden jars, mica-plates and tinfoil condensers were used. Discharge was effected by cutting through the gutta-percha-covered conducting wire by a smart blow of a knife connected to earth, and thus the troublesome false discharge-marks caused by slow discharge of the condensers were eliminated. The discharge of the jar through a caoutchouc tube filled with water, or through a wet string, gave, as it appeared, a manifold series of spark-marks surrounding the whole cylinder, but there was no difficulty in establishing the commencement of the discharges. SIEMENS had, on many grounds, deemed it probable, especially as being in accordance with the results obtained by FIZEAU and GOUNELLE, that the velocity of transmission of electricity would be found proportional to the specific conductivity of the material, and he repeated the experiment with a caoutchouc tube filled with sulphate of zinc, 100 ft. long, 0·784 inch (20 millimètres) diameter, but was unable to find any difference of time between the direct discharge-mark and that produced by the first partial discharge through the tube. A difference of one five-millionth of a second could easily be observed, so that it is certain that the velocity of transmission of electricity in liquids must exceed 800 German miles per second. Now the conductivity of copper is at least 200,000,000 times that of sulphate of zinc,—and therefore, assuming that the velocity of electricity is proportional to the specific conductivity, the velocity in copper will be at least 160,000,000,000 miles per second. That electricity is con-

ducted more quickly in electrolytic conduction than in metals of the same conductivity, no one would assume. The contrary is probable, because in electrolytic conduction molecular action comes into play.

By experiments carried out on long telegraph lines the question had to be determined, whether to electricity as to light a determinate measurable velocity can be ascribed, or whether the values of retardation measured by the different observers ought to be wholly or in great measure attributed to the retarding influence due to the inductive capacity of the line. To this end experiments were made in close succession on lines differing as much as possible in length, and in each case the electrostatic capacity of the line was measured. The first set of experiments indicated a velocity of 126,000 miles per second; another set 143,000 miles per second; a third set gave a mean of 149,916 miles per second; and a fourth, upon which less confidence is placed, 169,092 miles per second. The measurements of the electrostatic capacities of the lines over which the velocity was measured tend to show that the retardation must be due to some other cause than the influence of inductive capacity.—POGGENDORFF's *Annalen der Physik und Chemie*, 1875.

ELECTRO METALLURGY. See METALLURGY, ELECTRO.

ELEMI. (Vol. ii. p. 252.) It appears that in 1820 a gum resin was introduced into Europe, having much the character of the ordinary gum elemi, and was used by varnish makers. BAUP examined it, and found that besides an essential oil, it consisted chiefly of some resinous substances soluble in water, but differing from one another in their solubility in alcohol. These he named *Bryoidin*, *Breidin*, and *Amyrin*.

The composition of elemi is given as:—

An essential oil	$C^{10}H^{16}$
Crystallisable resin	$2(C^{10}H^{16})H^2O$
Amorphous resin	$2(C^{10}H^{16})2H^2O$
Bryoidin	$2(C^{10}H^{16})3H^2O$

N. Rep. Pharm., by PH. PHOEBUS.

ELEMI, ESSENTIAL OIL OF. By distillation of elemi, an essential oil of an aromatic character passes over. The peculiar smell of elemi is due to this essential oil. See ELEMI.

EMERALD-BERYL. NEW SOUTH WALES.—The name emerald is usually reserved for the deep green-coloured stones fit for jewellery, while the less beautiful and pale varieties are termed beryls.

The emerald is said to occur mixed with granite detritus in Paradise Creek, and near Dundee. Also in gneissiform dykes on the summit of Mount Tennant, and at Lanyon, to the west of that mountain; in the granite at Cooma, and in Mann's River, with other gems. In some cases the beryl is probably meant.

The beryl is much more common; it is found at Elsmore associated with quartz and crystals of tinstone. The beryl crystals, which are often very thin and fragile, are seen interlaced with and seated upon tin crystals.

At Ophir the beryl occurs in white felspar with quartz and white mica; one crystal was ½ in. through, of a pale transparent yellow green colour and vitreous lustre. Its sp. gr. = 2·708. A very fine white beryl, weighing about 100 carats when cut, has been found in Perthshire.

EMODIN. This compound, $C^{15}H^{10}O^5$, accompanies chrysophanic acid, and is found in rhubarb root to the extent of about 2 per cent. of the latter. It bears to chrysophanic acid a relation similar to that of purpurin to alizarin. DE LA RUE and MÜLLER, as also ROCHLEDER, obtained on the analysis of emodin tolerably concordant numbers, and proposed the formula $C^{40}H^{30}O^{13}$.

To obtain emodin, crude chrysophanic acid is boiled with soda lye, and filtered whilst boiling. Chrysophanic acid remains almost entirely undissolved, whilst all the emodin is taken up with a blood-red colour, and is precipitated by acids from this solution in amorphous yellow flocks, which are purified by re-crystallisation from boiling alcohol at about 80 per cent. The colour of emodin is not so light a yellow as that of chrysophanic acid, but inclines to orange.—*Anthracen*, by G. AUERBACH. Translated by WILLIAM CROOKES, F.R.S. See CHRYSOPHANIC ACID.

ENYSITE. A sulphate of copper and alumina. This mineral was obtained from the caves at the old quay, St. Agnes, Cornwall, where it occurs in the form of a bluish green stalagmitic crust. The water, from which this crust was deposited, has percolated through the ground, below the enclosures in which formerly the copper ore (sulphide of copper) was stocked previous to its being shipped for South Wales. According to Mr. J. H. COLLINS, this mineral has a hardness of 2·24, and specific gravity of 1·69. Its composition is given:—

Water	30·42
Sulphuric acid	8·12
Silica	3·40
Alumina	29·85
Oxide of copper	16·91
Lime	1·35
Carbonic acid	1·05

with traces of chlorine, soda, and oxide of iron.

'The mineral,' says Mr. COLLINS, 'is no doubt of comparatively recent formation, but as it has very marked characters, and none of the appearance of a mechanical mixture, Dr. FOSTER and myself have agreed to call it *Eggsite*, after our kind friend, the late JOHN S. ENYS, F.G.S., to whom the cave belonged, in which it was found.'—*Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain and Ireland*, August 1876.

EOSIN. (ἠώς, *the red of the morning.*) BAEYER states that eosin was first produced commercially at the Baden Aniline Works by CARO, and by him introduced to the trade. It appears to be a bromide of fluorescine, and is obtained by treating resorcin with phthalic acid, and then the new body fluorescine with bromine. BAEYER suggests the following experiment to show the relations of eosin. A portion of the colouring matter is agitated with water and sodium amalgam. The solution is soon decolorised, the bromine of its composition being removed, and colourless fluorescin produced. If now water be added, and a few drops of potassium permanganate solution, the fluorescin changes to fluorescein, and the liquid becomes bright green, and almost opaque in reflected light. Eosin is a potash salt of resorcine, which is largely soluble in water. Eosin has a beautiful red colour, recalling that of rosaniline, but inclining more to garnet red. In commerce it appears as a brownish red powder, showing here and there facets, with metallic lustre. It is soluble in water and in alcohol, and its solutions are strongly fluorescent. Upon examination it was found to contain no nitrogen, and to evolve bromuretted hydrogen on heating, leaving a carbonaceous residue containing bromide of potassium. Distilled with zinc dust, it afforded benzol. Its aqueous solution, treated with an acid, threw down a brick-red powder, which re-crystallised from glacial acetic acid, appeared as yellow prisms having a composition, $C^{20}H^8Br^4O^5$, a formula confirmed by the analysis of the barium salt, $C^{20}H^6Br^4BaO^5$. From these data HOFMANN concluded that eosin must belong to that remarkable group of bodies with which BAEYER has enriched chemistry, being a tetrabrominated fluorescein, a derivation of a body which he obtained by fusing resorcin with phthalic oxide. HOFMANN's further investigations proved eosin to be the phthalein of dibrom-resorcin. See WATTS's *Dictionary of Chemistry*.

REIMANN's *Färberzeitung* says:—Although eosin in body is distinguishable from the red coal-tar colours (magenta, &c.) by its greater solubility in water, and by the splendid fluorescence of the solution, it may often be necessary to examine if this costly dye is unsophisticated.

For this purpose the best reagent is sulphuric acid diluted with four volumes of water. With this liquid, magenta and corallin give a golden yellow, and saffranin a violet blue solution, while eosin remains undissolved, forming an orange red coagulum. If previously in solution, it is precipitated by the dilute acid, whilst possible impurities remain undissolved.

To detect eosin upon the fibre a concentrated aqueous solution of sulphate of alumina is prepared (one part in 4 of water). The reaction which ensues is not produced by any other dye-ware. The lakes are well known to be soluble in the solutions of certain salts of alumina and tin. On treating a dyed cloth with a hot solution of sulphate of alumina, the lakes of cochineal, and all other natural red colours are stripped; tar colours, such as magenta, corallin, and saffranin, dissolve as such, whilst eosin red remains almost completely untouched.

Eosin yields lakes with the oxides of the heavy metals, which, unlike the lakes of cochineal and of the woods, are soluble in water, but insoluble in precipitants, such as in the sulphate of alumina.

Eosin is sometimes adulterated with starch. To detect it, it is recommended to drench a portion of the eosin with alcohol at 96 per cent., which ought to give a clear solution. To distinguish eosin from coal-tar colours, and from alizarin red, WAGNER proposes to moisten the tissues with collodion. If a white spot appears, the dye employed is eosin.—R. WAGNER: REIMANN's *Färberzeitung*, No. 4, 1876.

EOSIN. PRIMROSE, or *alcoholic eosin*. This is an eosin not soluble in water, but soluble in weak alcohol. It fixes readily upon silk, and gives finer colours than eosin, having more of a crimson shade, and being more saturated. Silk is best dyed in water containing the soapy liquors from silk bleaching acidified by acetic acid. The

dye is very fast, and is not affected by exposure to light, and far excels in beauty and in permanence the colours obtained from *saffranine*.

To distinguish eosin from saffranin and other colouring matters, the most striking reaction is its inverse transformation by debromisation into fluorescein. Under the influence of sodium amalgam fluorescein is very readily recognised by its splendid uranium green fluorescence.

M. R. WAGNER thinks the above process, which is due to M. BAEYER, is too delicate, and that the following may be depended on.

Collodion is coloured by all the dies derived from aniline, by Magdala red and alizarin. Eosin, on the contrary, is immediately discoloured by collodion.

REIMANN'S *Färberzeitung* recommends for the detection of eosin in red fabrics, that a concentrated aqueous solution of one part of sulphate of alumina in four of water be employed, in which the coloured pattern must be warmed. While cochineal and the logwood lakes, and the tar colours, such as *fuchsine*, *coralline*, and *saffranine*, are extracted, the eosin red remains untouched.

To test *eosin* for the above coal-tar colours, it is best to use sulphuric acid diluted with four times its volume of water; the eosin is precipitated as an orange red powder, whilst *fuchsine* and *coralline* with a yellow, and *saffranine* with a blue, solution remain dissolved.

WAGNER says a solution of *eosin* and *methyl eosin* treated with collodion is at once dissolved, whilst all the aniline colours are intensely coloured by collodion. Pyroxylin (gun cotton), which readily absorbs the aniline colours, is scarcely coloured by eosin.

BAEYER shows the eosin is readily converted into *fluorescein* when treated with sodium amalgam. The bromine of the eosin is thus abstracted, and fluorescein formed, giving in very dilute solutions its characteristic uranium-green fluorescence.—DING. *Polyt. Jour.* ccxx.

Eosin of a blue shade is now being sold, which gives wool a colour resembling *cochineal ponceau*. The dye is dissolved in water, and has considerable affinity for wool, no mordant being required except hyposulphite of soda.—REIMANN'S *Färberzeitung*.

Lead is the best fixing agent for it on cotton. The calico is printed with a solution of eosine thickened with gum, steamed, and then fixed with acetate of lead.

In silk dyeing it is found that eosine soluble in water does not give good results. Better colours are obtained from a modification of eosine called *Primrose*.

Upon wool, eosine gives cochineal shades. Eosine is used for making red ink. About 200 grains of eosin, dissolved in water, with a little sugar and gum, gives nearly a quart of good ink.

EOSITE. An aurora red mineral found with cerussite at Lead Hills. It is regarded as a species between molybdate and vanadate of lead.—A. SCHRAUF, *Jahrb. f. Mineralogie*.

ERINITE. A mineral said to have been found in the county of Limerick. The analysis by TURNER gave:—

Arsenic acid	33·78
Oxide of copper	59·44
Alumina	1·77
Water	5·01

It occurs in mammillary and reniform masses, having a drusy surface, and consisting of concentric layers.

ESPARTO. The *Lygeum Spartum* is the only species of the tribe *Phalaridee* which yields the valuable grass, now largely imported and used in the manufacture of paper. It is a handsome grass, which has extensive underground stems or soboles, and hard wiry leaves. See TEXTILE MATERIALS.

The importation of esparto is large. M. LOUIS LÉVY, exporter of esparto and iron ore at Oran, says Algeria exported in 1873 45,900,000 kilogrammes, or, in round numbers, 45,600 tons. M. LÉVY adds that in 1874 the exportation of Algerian esparto reached the quantity of 60,000 tons.

ETHYLENE. (Vol. ii. p. 200.) Olefiant gas. See COAL GAS.

EXPLOSIVE COMPOUNDS. See EXPLOSIVE AGENTS, vol. ii. p. 320. In the article referred to, several of the numerous preparations which have been from time to time introduced for blasting purposes were named and the compositions of the more important given, and their properties described. Since that period a few others have been introduced, which require some additional notice.

1. *Tonite, or Cotton Powder*, is the name given to a preparation analogous to gun cotton, but which is prepared by a process peculiarly adapted to the formation of a cotton powder. The following description will fully explain its manufacture.

The raw cotton as received from Manchester is first hand-picked to deprive it of its coarser impurities and foreign substances. It is then taken to a scutching machine, or 'devil,' where it is further cleansed and the fibres separated. It is then washed, dried, weighed out into 1 lb. lots, which are placed in tin-covered cans and taken to the steeping tanks, where it is thoroughly immersed in a mixture of nitric and sulphuric acids. After about four minutes' immersion it is taken out, the pound of cotton having absorbed about 20 lb. of acid, 12 lb. of which are expressed from it in a hydraulic press, leaving about 8 lb. still in the cotton. As the charges are removed from the press they are taken to a washing tank, and afterwards to a centrifugal drying machine, where the moisture is expelled from them. The cotton then undergoes another washing and drying; after which it is taken to the first mill, where it is passed between a pair of rolls and coarsely pulverised. From the first it is taken to a second mill, where it passes between rolls set more closely together, and where it consequently acquires a much finer degree of granulation. From the second mill the cotton powder—for such it has now become—is transferred to a tank of water, where it undergoes a final washing, so as to deprive every atom of the cotton of free acid. This washing is continued for some time, the pulp and water being kept in a constant state of agitation by means of a blast of air, which is forced through the tank. After settling and drying, the cotton powder is removed to the mixing house, where it is incorporated with other chemical ingredients in a pan under a pair of edge runners. After the mixing has been completed, the compound—now, cotton gunpowder—is taken to the drying-house, where it is placed in shallow trays with fine gauze wire bottoms. These trays are laid in a long row over a trough, through which a current of heated air is blown by a fan, the air rising, passing up through the cotton gunpowder and drying it. From the drying house the explosive is conveyed to the cartridge sheds, where it is filled into cases holding from an ounce to a pound, or any greater or less quantity that may be desired. The cartridges are subsequently packed in cases, and are stored in a large magazine on another part of the works. Thus, that which was at first a mass of harmless fibrous cotton has now become converted into a fine cream-coloured powder, capable of developing under certain conditions a vast amount of destructive power.

Nitrates of Sodium and Barium have been tried as substitutes for saltpetre in gunpowder, but the hygroscopic nature of the first, and the low percentage of oxygen in the other, have prevented their employment.

Nitro-starch has been proposed as a substitute for gunpowder, but it has not much power, and for blasting it is said to be worthless.

Vigorite is the name given to nitrated cane-sugar, which was discovered by Sobrero. As this is of a sticky, resinous nature, it is troublesome to manufacture, and it is especially difficult to free it from the adhering acids; therefore it is liable to undergo chemical change, and often spontaneous combustion ensues. Vigorite is difficult to explode, with even the strongest detonator caps, and it is said that its blasting power is not equal to nitro-glycerine.

Dualine is mentioned in EXPLOSIVE AGENTS, vol. ii. p. 321, as SCHULTZE's sawdust powder impregnated with nitro-glycerine. It was brought out in Germany by Mr. DITTMAR, but it really consists of ordinary sawdust, nitrate of potash, and nitro-glycerine. It does not appear to be much used.

Lithofracteur. (See vol. ii. p. 321). The manufacturers have now published the actual composition as the lithofracteur is now (1877) prepared by them:—

Nitro-glycerine	55 per cent.
Kieselguhr (*infusorial silica*)	21 ,,
Charcoal	6 ,,
Barium nitrate and bicarbonate of soda, or either .	15 ,,
Sulphur and manganese oxide, or either . . .	3 ,,

This is not very different from the composition previously given, the nitrate of barium and the oxide of manganese being the only agents which were not mentioned in the description previously given. According to report, lithofracteur does not possess any greater degree of power than dynamite, but it has not been sufficiently experimented upon to thoroughly test its power. Its composition appears to render it liable to spontaneous change; still, if carefully kept, there is no doubt that decomposition may be prevented for a long period.

M. BERTHELOT has lately published *Contributions pour servir à l'Histoire des Matières Explosives*, from which are selected the following tables:—

Quantities of Heat produced by the formation of Azotic Compounds from their Elements.

	Equivalents	Quantité de chaleur pour	
		1 équivalent	1 gramme
	gr.	cal.	cal.
Nitric ether, $C^4H^4(NO^6H)$	91	+ 31·0	+ 341
Nitro-glycerine, $C^6H^2(NO^6H)^3$	227	+ 25·0	+ 110
Gun cotton, $C^{24}H^{10}O^{20}(NO^6H)^5$	549	+ 502·0	+ 919
Picric acid, $C^{12}H^3(NO^4)^3O^2$	229	− 14·0	− 66·5
Picrate of potash, $C^{12}H^2K(NO^4)^3O^2$	267	+ 51·0	+ 186
Nitric acid, NO^6H	63	+ 19·0	+ 316
Nitrate of potash, NO^6K	101	+ 97·5	+ 926

Quantity of Heat produced by the complete combustion of Explosive Substances by means of free Oxygen (water supposed to be gaseous).

	Equivalents	1 équivalent	1 gr. substance explosive
	gr.	cal.	cal.
Nitric ether	91	305·5	3357
Nitro-glycerine	227	406·5	1786
Gun cotton	549	873·5	1572
Picric acid	229	605·5	2919
Picrate of potash	267	661·0	2473

This being the heat evolved by the combustion of an equivalent of the hydrocarbon by free oxygen, n, the number of equivalents of oxygen employed in the combustion, the heat evolved by various oxidants will be—

	Heat of combustion
Oxide of copper, $n\,CuO$	$A - 18{\cdot}6\,n$
„ lead, $n\,PbO$	$A - 25{\cdot}1\,n$
„ tin, $n\,SnO$; „ binoxide, $\frac{n\,SnO^2}{2}$	$A - 34{\cdot}9\,n$
„ antimony, $n\,\frac{SbO^3}{4}$	$A - 31{\cdot}0\,n$
„ mercury, $n\,HgO$	$A - 15{\cdot}3\,n$
„ bismuth, $\frac{n}{3}\,BiO^3$	$A - 6{\cdot}6\,n$
„ silver, $n\,AgO$	$A - {\cdot}3\,n$
Nitrate of lead, $n\,\frac{NO^6Pb}{6}$	$A - 5{\cdot}3\,n$
„ silver, $n\,\frac{NO^6Ag}{6}$	$A - 1{\cdot}1\,n$
„ potash, $n\,\frac{NO^6K}{6}$	$A - 1{\cdot}9\,n$[1]
Chlorate of potash, $n\,\frac{ClO^6K}{6}$	$A - 2{\cdot}5\,n$

Annales des Chimie et de Physique, October 1876.

The Temperature of Explosion has been determined by MM. LEYGUE and CHAMPION, who published in the *Comptes Rendus* the following results:—

	°
Priming powder for Chassepot	191
Fulminate of mercury	200
Powder {Chlorate of potassium / Sulphur equal parts}	200
Abel's gun-cotton pulp	205
Ordinary gun cotton	240

[1] Le composé supposé formé du carbonate de potasse.

	°
Powder { Sulphide of antimony / Chlorate of potassium equal parts }	260
Ordinary shooting powder	288
Gunpowder (Artillery)	295
Picrate of mercury, of lead, or of iron, detonate at	296
Torpedo picrate powder	315
Musket ditto	358
Gunpowder ditto	380
Saffron, artificial	315
Picric acid—picrate of potassium, of magnesium, and of ammonium	336
Nitro-glycerine detonates at from	256 to 257
Sulphur inflames in air	246

SPRENGEL'S *Explosives*.—Dr. SPRENGEL has recently introduced a class of compounds which are non-explosive during manufacture and transport. They are mixtures of a combustible and an oxidising agent, these substances being kept separate until they are required for use.

The most effective were—

1st. Mixture of nitric acid, sp. gr. 1·5, and any nitro compounds of the hydrocarbon series.

2nd. A mixture of nitro-benzine or picric acid with nitric acid; it explodes with a violence equal to that of nitro-glycerine.

3rd. Porous cakes of chlorate of potassium, saturated with sulphide of carbon or nitro-benzene, were found to be five times as effective in open granite quarries as an equal weight of gunpowder.—*Chemical Society's Journal*, (2) xi. 796.

BRAIN'S *Powder* is a compound of nitro-glycerine with an explosive base and consists of nitro-glycerine 25 to 40 per cent., and a mixture of nitrate of potash, chlorate of potash, charcoal, and wood sawdust (oak or ash). The wood dust is prepared so as to render it sufficiently porous to absorb the whole of the fluid nitro-glycerine, and each ingredient is finely powdered before mixing, and on the addition of the nitro-glycerine becomes of the consistence of hard putty, being still sufficiently plastic to allow of its being pressed out to fill the hole.

It is asserted that with half the amount of nitro-glycerine used in dynamite this powder has been proved more powerful and can be detonated with a smaller amount of fulminate; at the same time, the base being itself detonated, ensures the perfect explosion of the whole of the nitro-glycerine, and leaves no gases when detonated in close galleries except the products of combustion. Miners are said to have repeatedly, but not very wisely, gone into shafts and headings within three or four minutes after the explosion of some pounds of it without experiencing any ill effects from it either in head or lungs.

It is said to be equally capable of detonation when frozen, thereby avoiding the dangerous necessity of thawing it—a process which has caused so many accidents with dynamite.

With 40 per cent. of nitro-glycerine BRAIN'S powder is impervious to water, and has been detonated after lying many hours in the bed of the Severn. The weaker qualities, with a smaller proportion of chlorate and nitro-glycerine, are for use in granite quarries, where it is very efficacious in making leading cracks without breaking up the stone too much. Some of this explosive made in September 1873 had not undergone any change, or shown any tendency to separate or to become acid in 1877.

Abstract of a series of experiments conducted at the Wildberg mines, Prussia, by the superintendent, Mr. FERDINAND:—

1. A frozen cartridge of BRAIN'S powder was placed between two boards, and a weight of 25 lb. dropped through a space of 6 ft. directly upon the cartridge.

The second fall of the weight burst open the cartridge.

The third fall of the weight scattered the contents of the cartridge over the board.

2. The weight was permitted to fall direct upon frozen cartridges without producing any explosion.

3. BRAIN'S powder was placed on iron plates and the weight referred to frequently dropped direct on the powder without exploding or igniting it.

4. Frozen cartridges of BRAIN'S powder were thrown 10, 20, and 25 ft. high into the air, and fell on rough stones without exploding.

5. Several cartridges of BRAIN'S powder were thawed and put on an iron plate. Although the weight, by repeated falls, flattened, burst, and scattered the contents of the cartridges, yet no explosion ensued.

6. Cartridges of BRAIN'S powder were burnt in a close chamber, but produced no intolerable gases and consequently no headache.

7. A BESSEMER rail was taken, to which cartridges of dynamite, lithofracteur, and BRAIN'S powder, each of equal weight, were in turn fastened.

The dynamite cartridge when detonated bent the iron.
The lithofracteur ditto ditto
The cartridge of BRAIN's powder *broke* the rail in two parts.

8. Tests in the mine itself showed BRAIN's powder to be a powerful explosive, particularly in hard tough ground, whilst, from its perfect and complete detonation, the miners were enabled to return to their work more speedily after a blast, and to continue operations without experiencing any unpleasantness either in the chest or lungs.

Sebastin is the name of another modification of the nitro-glycerine compounds, the invention of Mr. GUSTAV FAHNEHJELM, of Stockholm.

In the ordinary dynamite the infusorial earth cannot keep and retain the oil absorbed under certain circumstances. When such a dynamite is exposed to changes of temperature, and especially when it has become frozen, and then passed into a pasty state again, a part of the nitro-glycerine becomes separated from the earth. The danger resulting therefrom is not greatly to be feared if the nitro-glycerine is absorbed by a charcoal of the kind used in the improved process here in question. In order to produce a charcoal having the required qualities, the carbonisation or coking must be done in such a manner as to completely destroy the organic substances, and to produce as porous a charcoal as possible. For this is selected, by preference, young trees or striplings, or branches of poplar, hazelwood, or alder tree, and they are burnt in an open fire. When the wood has been consumed, the fire is not extinguished by means of water, but left to go out of itself. In this way is obtained a very inflammable and very porous charcoal, which can absorb more than five, and approaching six times its weight of nitro-glycerine, without any risk of the separation of the oil. The charcoal is pulverised in a wooden mortar, but it should not be reduced to too fine a powder, else it will not so completely absorb the nitro-glycerine. The charcoal produced in the ordinary way, or by closed fire, is quite different as regards absorbing power. Charcoal of the fir trees may, however, be used, and may acquire nearly the same qualities, that is, if charred a second time in a special oven.

By mixing the different kinds of charcoal, a material may be obtained possessing the required absorbing qualities, and an explosive compound may then be obtained of great power without loss of the necessary consistency, that is, without being too dry, which is not desirable. The charcoal not only serves as the best absorbent for the nitro-glycerine, but it plays also an important part in the combustion. The nitro-glycerine in exploding decomposes into steam, carbonic acid, nitrogen, and oxygen. In the explosion of dynamite with inert base, the oxygen goes away without being utilised, but in the explosion of this new compound (the new sebastin) a part of the absorbent charcoal is burnt by means of the liberated oxygen. The quantity of gas is thus augmented, and also the development of heat, whereby again the tension of the gas is augmented. As, however, the quantity of charcoal necessary for the complete absorption of the nitro-glycerine is, in all cases, much larger than that which can reduce the excess oxygen produced at the explosion into carbonic acid, a salt is added to the compound, which also, by the combustion, gives an excess amount of oxygen, which may contribute to burn the rest of the charcoal. For this purpose Mr. GUSTAV FAHNEHJELM uses, by preference, nitrate of potass, which may be added without any risk, and which gives the explosive compound a very much greater rapidity or vehemence, and consequent force of explosion.

The composition of the sebastin depends upon the objects for which it is to be used, and the effects intended to be produced. The strongest compound—and even in this there is stated to be no risk of the separation of the nitro-glycerine—is composed of 78 parts by weight of nitro-glycerine, 14 of the wood charcoal, and 8 of nitrate of potass. When less power is required, the proportions are varied, the second quality consisting of 68 per cent. by weight of nitro-glycerine, 20 of the charcoal, and 12 of nitrate of potass. To show the relative strength of the compounds, the inventor says:—Let the dynamic force of pure nitro-glycerine be represented by the number 2,844,043·6, then the dynamic force of the sebastin No. 1, as above, will be indicated by 2,416,577, and of the sebastin No. 2 by 1,933,079·4, while that of dynamite No. 1 (consisting of 75 per cent. of nitro-glycerine, and 25 per cent. of infusorial earth), will be represented by 1,674,694. For the above qualities of sebastin, the increased effect produced by the greater rapidity of the explosion must be taken into account also. The increase has not yet been measured, but is estimated at 10 per cent. The sebastin may also be compounded in other proportions of the constituent parts, but the object being to produce explosive compounds of the greatest force, which it is possible to employ without danger, he merely mentions that the proportion by weight may vary from 50 to 80 per cent. of nitro-glycerine, 15 to 35 per cent. of the prepared charcoal, and 5 to 20 per cent. of the nitrate of potass.

It is distinctly to be understood that Mr. FAHNEHJELM does not claim the combination of nitro-glycerine and wood charcoal in general, but the production of a solid

compound of nitro-glycerine, and a wood charcoal prepared in the special mode or modes set forth, the nitro-glycerine being the principal ingredient, which is absorbed by the wood charcoal to the extent of more than five, and reaching nearly six, times its weight, without risk of this compound parting with any of its oil as set forth; and, secondly, the addition of such solidified nitro-glycerine of a quality of nitrate of potash, or other suitable salt, not exceeding 20 per cent. of the whole mass, for the purpose of rendering the combustion as complete as possible.

Acetylene of Copper.—The dangerously explosive character of acetylene copper is well known. Many serious accidents have occurred from its presence—spontaneously formed—on copper pipes employed for conveying illuminating gas. Such accidents have resulted from slight blows with a hammer or some other iron tool given by workmen when engaged in making repairs, &c. Another copper compound has recently been prepared, which, when mixed with chlorate of potash, forms an explosive, which it is proposed to use for filling percussion caps, torpedoes, &c. The mode of producing this compound, or salts of copper, is as follows:—To a solution of sulphate of copper is added enough hyposulphite of soda, in solution, entirely to destroy the blue colour. To another portion of the blue vitriol solution, ammonia is added, until the blue precipitate, at first formed, dissolves to a dark-blue solution of ammonia-oxide of copper. The two solutions are now mixed; and after long standing a violet-coloured salt crystallises out of the beautiful blue liquor. It is this salt which becomes explosive when mixed with chlorate of potash. The composition of the violet-coloured salt above referred to, and which constitutes the new explosive, is not given by the authority quoted; neither is any reference made to the probable cause of its explosive nature. It may possibly be due to the nitrogen imparted to it by the ammonia. —*Polytechnisches Notizblatt.*

Lignose.—A new blasting agent called 'lignose' has been invented by M. TRUTSCHLER-FALKENSTEIN, and made of woody fibre prepared with nitro-glycerine. Extensive experiments have lately been made with it in some coal-pits in Upper Silesia. In the Mathilde pit it has been used for several months, and is stated to have at least three times the force of an equal weight of block blasting powder, while its price is 120 marks per cwt., as against 51 marks for powder. The lignose, however, sometimes shows irregularity in its action, and it is very sensitive to moisture. The latter feature must be specially unfavourable to a large introduction of the agent; though it has been found that cartridges of it explode (with a certain degree of moisture), with violent detonation, if placed on about 15 gr. dynamite, or if very strong percussion caps are used. In the Gottessegen pit the results of experiments with lignose were much less favourable; and the cost, relatively to action (as compared with powder), was regarded as higher. The gases from the substance were also found prejudicial to the eyes and the respiratory organs. In the Florentine pit there were three accidents in quick succession from unexpected explosions of 'lignose.' The superiority of the substance does not therefore seem demonstrated at present.

Pantopollit is a new and cheap variety of dynamite, produced at Opladen, in the Rhine country. It contains some naphthaline dissolved in nitro-glycerine, the object of which is to prevent the formation of the injurious hyponitric vapours. In experiments made with it in the Friedrichsthal pit, the blasting action was quite good, but the smoke and smell were so unpleasant, producing severe pains in the head and chest, that the place could not be worked for long afterwards. A charge of 10 centimètres pantopollit is reckoned equal to 30 centimètres ordinary blasting powder.

Materialite.—An explosive compound manufactured at Fabry in Switzerland. It appears to be of the dynamite variety, but is stated to be far more dangerous.

Six thousand lb. of this substance, which had been seized by the French Custom House officers (its importation being prohibited, an attempt was made to pass it as artificial manure), exploded at Fort Larmont, near Pontarlier, in January last (1877), completely destroying the fort and killing six men.

There are many known chemical compounds liable to spontaneous decomposition, and no doubt many combinations with which we are imperfectly acquainted, which are of a dangerously explosive character. Especially may be named the chloride of nitrogen, the iodide of nitrogen, and several other analogous compounds. Some notice of these will be found in Dr. QUESNEVILLE's *Moniteur Scientifique.*

Two instances of unexpected decomposition, accompanied with some degree of violence, have been brought to the notice of the *Scientific American.* The first happened with iodide of strychnia: a bottle, in which some of the salt had been long kept, was held near the fire, to warm the glass and loosen the stopper. An explosion suddenly occurred, scattering the glass and badly wounding the hand. The other accident was related by Mr. B. F. MCINTYRE, at a meeting of the Alumni Association of the New York College of Pharmacy. On distilling essential oil of bitter almonds over nitrate of silver, to free it from prussic acid, towards the end of the operation the

material in the retort violently exploded, breaking all the glass apparatus in its proximity, but doing no further damage. Neither explosion can be very easily explained. In regard to the iodide of strychnia, it is supposed that the substitution compound had formed, on decomposition, some iodide of nitrogen, in a somewhat similar manner to the production of that substance, when iodine is treated with an excess of ammonia. As to the reaction which occurred between oil of bitter almonds and nitrate of silver, it may be said not to be altogether extraordinary, as the silver is known to readily form explosive compounds with a number of organic substances. The only wonder is that no mention has been made of it before this time, for the rectification of the essential oil over nitrate of silver is not an unfrequent operation.

The following *Experimental Researches on Explosive Substances*, by MM. Roux and Sarrau, are of interest :—

'It had been found that a substance called algunnite, of the dynamite variety, might be exploded by two methods. Simple explosion is caused by the ordinary ignition of the substance, and detonation by the percussion of a strong priming of fulminate of mercury. By these two kinds of explosion, very different pressures are produced, and the authors have endeavoured to measure the relative intensities of these pressures, by the quantities of each explosive substance respectively required to rupture bomb-shells identical in form and dimension. They have shown further, from recent experiments, that this property of double explosiveness belongs to the greater number of other explosives, besides algunnite. The charge of gunpowder necessary to produce rupture was 200·62 grains (13 grammes), by simple explosion. The ratio of 13 grammes to the rupturing charge of another substance is a measure of the force of the substance, the force of gunpowder by simple explosion being taken as 1. The subjoined table contains the explosive force, thus experimentally obtained, of various substances, together with the proportion of permanent gases produced by simple explosions, in percentages of the weights of the substances and the quantity of heat disengaged by 1 kilogramme and 1 lb. of the substance in French and English units respectively. It is shown that the simple explosive force of gunpowder is more than quadrupled by detonation; that the simple explosive force of a substance is proportional to the product of the weight of gases disengaged by the heat; and that the detonating forces for six of the substances, are nearly proportional to the heat disengaged.

Results of Experiments on Explosive Substances.

Substance exploded	Explosive Force, that of Gunpowder by simple explosion		Relative Weight of Gases	Heat disengaged by			
				1 kilogramme, French measure		1 lb., English measure	
	2nd order	1st order		2nd order	1st order	2nd order	1st order
	Ratio	Ratio	Per cent.	Units	Units	Units	Units
Fulminate of mercury	—	9·28	—	—	752	—	1,354
Gunpowder . .	1·00	4·34	41·4	731	732	1,316	1,318
Nitro-glycerine .	4·80	10·13	80·0	1,720	1,777	3,097	3,200
Pyroxyle . . .	3·00	6·46	85·0	1,056	1,060	1,902	1,909
Picric acid . .	2·04	5·50	80·2	823	868	1,491	1,563
Picrate of potass .	1·82	5·31	74·0	787	852	1,417	1,534
,, ,, baryta .	1·71	5·50	71·9	671	706	1,208	1,270
,, ,, strontium .	1·35	4·61	62·4	637	745	1,147	1,342
,, ,, lead . .	1·55	5·04	66·8	555	663	999	1,194

Comptes Rendus de l'Académie des Sciences, October 5, 1870.

Mr. Alfred Nobel read a paper before the Society of Arts *On Modern Blasting Agents*. One portion of that paper was of considerable scientific importance, and we give it a place in these pages.

By aid of repeated calorimetric tests, made at the Depôt Central des Poudres, Paris, Messrs. Roux and Sarrau have sought to determine how much heat the explosion, or rather detonation, of various fulminates produces. They have thus found for nitroglycerine 1,784, for gun-cotton 1,123, and for picrate of potash 840 units of heat, which, multiplied by the mechanical equivalent per unit, gives 778, 489, and 366 mètre-tons per kilogramme of the substance, as against 370 for the best sporting powder, and 267 for the ordinary French mining powder, which is of a very inferior quality. Comparing these figures with the heat produced by the combustion of gunpowder, as found by Mr. Abel (705 units), and taking it as 1·00, the mechanical power which nitro-glycerine is capable of performing would rank as 2·53, that of gun-cotton as 1·59, and picrate of potash 1·19.

M. Berthelot, following a different method, purely theoretical, arrives at much lower figures for the heat produced by the combustion, and for the amount of work it represents. He admits that at the very high temperature, which is a very general feature of explosive combustion, no complex chemical combination can exist, and that only elementary compounds, such as water vapour, carbonic oxide, and carbonic acid, will be formed; so that when the chemical composition of such explosive substances is known, which are entirely converted into gas, it is easy to determine, without recourse to experiments, the nature of the gaseous products formed at the moment of their explosion. Hence, for instance, nitrate of ammonium of which the formula is NH^4NO^3, would split up into $N^2 + O^2 + (H^2O^2)$.

Starting from this point of view, the correctness of which certainly does not appear to admit of the slightest doubt, M. Berthelot computes, from well-known tables, the heat produced by the formation of the gaseous products from their elements. He further calculates the units of caloric developed in the formation from its elements of the explosive substance to be dealt with, and takes it for granted, of course, that as much heat must be absorbed in disuniting the chemical tie as was freed in forming it. The heat lost in that operation he deducts from the sum of heat produced by the reunion of the disconnected elements, the balance representing the heat really developed in the explosive combustion. Thus, for each 227 grams of nitro-glycerine, which the explosion transforms entirely into carbonic acid, water, nitrogen, and oxygen, M. Berthelot calculates the heat produced by the formation of the carbonic acid and water from the elements at 430,500 units, and the heat produced by the formation of the nitro-glycerine itself from its prime elements at 130,500 units, which, deducted from the total of 430,500, leaves 300,000 units of caloric freed, or 1,320 units per gram of nitro-glycerine exploded.

The main drawback of that method is the difficulty in arriving at anything like a fair estimate of the heat developed in the course of formation of a complex organic compound, such as, for instance, nitro-glycerine or gun-cotton. It is therefore probable that the figures arrived at by Messrs. Roux and Sarrau, by direct calorimetric tests, are, until now, the more reliable.

The author has, for the last six years, made regular use of another method, which has been of great utility to him in enabling him to draw a tolerably correct comparison between the power of various detonating substances. It is based on measuring their ballistic power, and, though certainly open to some objections, it has the advantage of being extremely handy and sufficiently accurate for the object in view.

A mortar test is, indeed, more reliable for comparing detonating explosives than for slower compounds, for, in the latter case, the projectile may have left the mortar before the combustion is completed, while, in the case of fulminates, their explosive conversion is so rapid, that in all probability it is completed before the projectile has begun to move at all, thus acting upon it with the whole force of its initial tension. This is further confirmed by the fact that the bore of the mortar can be made far shorter than for testing gunpowder without any considerable falling off in the range of projection.

The following table (see next page) shows the results of mortar tests made with various detonating mixtures, the elevation of the mortar in each case being 10°; also the results obtained in testing the ballistic power of detonating gun-cotton, nitro-glycerine, dynamite, and various other compounds. From the figures therein contained, some important conclusions may be drawn.

If the ballistic power of detonating nitro-glycerine is expressed by 100, then, in their comparison, weight for weight, compressed gun-cotton ranks as 71; dynamite, consisting of 25 per cent. of kieselguhr and 75 per cent. of nitro-glycerine, as 72; ammonia powder as 83; gunpowder mixed with 20 per cent. of nitro-glycerine as 50; gun-cotton mixed with its own weight of nitro-glycerine as 83; Curtis and Harvey's strongest blasting powder, ignited with a detonator-cap, as 25; fulminate of mercury as 30; and lithofracteur of the strongest kind (made of the ingredients specified in the Government licence for that material), as 50·5.

In this estimate no deduction has been made for the power exercised by the fulminate of the detonator-caps, it being the same for all preparations, except gun-cotton, for which 0·16 gram additional weight of fulminate was used.

Interesting as it may be to compare the relative power of explosive substances, weight for weight, the power which they are capable of exercising, bulk for bulk, is of far greater importance in their application to blasting. It is easily computed when their specific gravity is known, which has been found for nitro-glycerine, 1·6; for gun-cotton, 1·00; for dynamite No. 1, 1·65; for ammonia powder, 1·55; for gunpowder, 1·00; and for lithofracteur, 1·70, which is also the specific weight of dynamite No. 2, and of most nitro-glycerine preparations containing large quantities of metallic salts.

No. of Experiment		Parts by Weight	Weight of Charge in grains	Distance thrown (shot = 18 lbs. weight) in links			Average in links
				1st charge	2nd charge	3rd charge	
1	Nitro-glycerine pure	—	6	308	297	295	300
2	Nitro-glycerine Compressed gun-cotton	1 1	6	295	302	300	299
3	Potassium chlorate Charcoal Nitro-glycerine	122 20 50	7	250	241	243	245
4	Potassium nitrate Charcoal Nitro-glycerine	101 17 50	10	279	263	281	274
5	Ammonium nitrate Charcoal Nitro-glycerine	80 0·5 20	8	290	300	309	300
6	Gun-cotton compressed	—	7	295	310	300	302
7	Patent gun-cotton powder	—	8	291	303	286	294
8	Fulminate of mercury	—	10	158	—	—	158
9	Fulminate of mercury Chlorate of potassium	80 20	10	220	219	219	219
10	Gunpowder mealed Nitro-glycerine	80 20	10	303	298	296	299
11	CURTIS and HARVEY's extra strong blasting powder exploded with detonator	—	20	341	340	330	337
12	Picrate of potassium Nitrate of potassium Nitro-glycerine	60 30 10	7	222	227	229	226
13	Sodium nitrate Charcoal Sulphur Nitro-glycerine	65 17 10 30	10	283	307	313	301
14	Lithofracteur[1] as per Government license:— Charcoal Kieselguhr Barium nitrate Sulphur Nitro-glycerine	 6 21 14 6 55	7	218	211	205	211
15	Dynamite No. 1, consisting of— Nitro-glycerine Kieselguhr	 75 25	7	290	316	307	304

When their power is compared, bulk for bulk, the various explosives range as follows:—

Nitro-glycerine	100
Ammonia powder	80
Dynamite No. 1	74
Lithofracteur	53
Gun-cotton	45
CURTIS and HARVEY's blasting powder fired by detonator	175

Influence of the Fuse on Compressed Gun-Cotton.—MM. L. CHAMPION and H. PELLET object to the use of fulminating mercury in the powdered state, not only because it is dangerous in that condition, but because it cannot be conveyed separately from the capsule of which it is to determine the explosion.

They made experiments with compressed fulminate, and found that these difficulties were obviated; that a charge of 2 grams in a brass capsule $\frac{2}{10}$ths of a millimètre thick was sufficient to explode *dry* gun-cotton; but if *damp*, the thickness of the tube must be slightly increased, as the thickness of the envelope is important in determining the explosion.

A number of small explosions were found to be equivalent to the explosion of a large quantity of fulminate. Six small fuses bound together, and one of them ignited, was found sufficient to cause the remainder to explode, and to explode the gun-cotton in connection with them.—*Comptes Rendus*, lxxxi.

Gunpowder.—Messrs. CURTIS and HARVEY have lately introduced a new gunpowder which they call their E. S. M. powder. Upon this powder we have been favoured with the following remarks by Mr. G. G. ANDRÉ, C.E.:—

In pointing out the conditions upon which the merits of an explosive agent are founded, the use to which it is to be applied must be borne in mind. Great attention has been devoted to the composition and manufacture of gunpowder for use in fire-arms, and the proportions of the several constituent substances, now, with but slight

[1] This is the strongest mixture of lithofracteur ingredients as published by the manufacturers. The slightest addition of soda bicarbonate or manganese dioxide indicates a decrease of power, as shown by numerous mortar tests.

rate now, generally adopted, are undoubtedly those which are the most suitable for the purpose. It has been found that a comparatively slow burning powder gives a greater projectile force than one which burns more rapidly, while the strain upon the gun is much less in the former case than in the latter. To obtain these advantages, the composition of gunpowder is so proportioned as to give a large volume of gas, with a sufficiently slow rate of combustion. For use in large guns, the rate of burning is still further reduced by increasing the dimensions of the grains.

But for blasting powder these conditions are reversed. Here the strain from which it is desirable to relieve the gun is alone serviceable, since, in blasting rock, the end proposed is to rupture the envelope. Manufacturers have not, hitherto, sufficiently borne this condition in mind, and hence has arisen the wide diversity to be found in the composition of blasting powder. For the sake of cheapness, proportions have, in many instances, been adopted, which are certainly far from those required to give the greatest rending force. But in the E. S. M. powder the proportions are used which both theory and practice show to be those from which the maximum of that force is to be obtained. As a consequence, we have in this powder extreme rapidity of combustion, combined with the evolution of a large volume of gas and the generation of great heat. The quality of the charcoal used plays an important part in bringing about these results. The physical qualities of the powder also are those which are known to be most favourable to rapid combustion. The grains are small and irregular in shape, conditions which leave the largest possible surface exposed to the heated gases. A consideration of these facts will undoubtedly convince those who are familiar with the use of gunpowder that the E. S. M. is, for the uses to which it is intended to be put, greatly superior to the other kinds commonly employed. Of this superiority, indeed, the results of practice, as reported in the pamphlets and circulars, afford evidence.

F

FAMATINITE. A nickeliferous mineral, of a reddish colour, from Cerro de Pasco, in Peru. The composition was found to be—

Cu	Sb	As	S
47·93	12·74	8·88	30·45 = 100

A. Frenzel, *Jahrbuch für Mineralogie.*

FEEDING STUFFS. Dr. A. Voelcker gives the following as the compositions of several feeding stuffs:—

	Hemp Cake	Refuse Maize-cake	Sorghum Seed	Chinese Oil Bean-cake	Liebig's Meat Powder
Water	10·57	12·46	12·17	8·30	5·57
Fat	11·17	5·01	3·08	6·67	15·20
Albuminoids	29·56	11·06	7·47	39·25	74·62
Extractive matter	18·03	64·71	72·44	34·25	—
Fibre	24·20	4·06	3·35	5·03	—
Ash	5·47	0·80	1·49	5·80	4·61
Nitrogen	4·73	1·77	1·19	6·28	11·77

Hemp cake is chiefly used for adulterating linseed cake. The maize cake is obtained in the manufacture of Indian corn flour. Meat powder is the refuse fibre remaining after the preparation of Liebig's extract.

FEATHERS. (Vol. II. p. 332.) There is nothing new since the publication of the last article. The importation of feathers for *beds* in 1875 appears to have been large.

	Cwt.	Value.
From Russia	6,354	£36,102
„ Germany	5,748	38,032
„ France	5,561	16,745
„ Italy	1,732	19,388
„ other countries	3,042	15,910
	22,437	126,177

The importation of *ornamental* feathers has also increased.

	Lb.	Value.
From Belgium	3,475	£15,533
„ France	131,634	237,516
„ Egypt	26,665	50,229
„ Tripoli and Tunis	4,041	14,853
„ Morocco	4,173	19,641
„ Argentine Republic	10,968	8,422
„ Malta	4,722	9,441
„ British South Africa	53,992	293,866
„ British East Indies	27,043	37,197
„ other countries	29,387	26,099
	296,090	712,199

FERMENTATION. (Vol. ii. p. 339.) The action of borax on fermentation has been shown by PASTEUR to be of a repressive character. Vinous fermentation appears to be entirely stopped by the addition of a small quantity of the borate of soda.—*Comptes Rendus*, sundry papers.

FERRO-MANGANESE. Metallic manganese seems to play, in the metallurgy of iron and steel, a double part:—

1. It reduces the oxide of iron by reason of its great affinity with oxygen. The application of spiegeleisen and ferro-manganese, and their power of reduction, when applied to oxide of iron dissolved in a bath of steel, according to the BESSEMER or SIEMENS-MARTIN process, may thus be explained. Steel in a state of fusion seems to absorb oxygen with greater ease the less carbon there is mixed up with it, for if there be carbon, carbonic oxide would be produced and the iron would not be oxidised. Since there was more and more demand for the softer kind of steel, an energetic agent of reduction was in all the greater demand. It was, therefore, a great step forward to be enabled to thus condense in a special alloy of iron and manganese the ferro-manganese, which proved to have the productive power that was required. The small quantity which it is necessary to use reduces to almost nothing the carbon, which is re-dissolved in the steel, and thus a steel of unexpected softness is produced.

The use of ferro-manganese for the production of soft steel of prime quality seems to have a great future. The substitution of the cast metal of extra softness for iron in metallic constructions is in Europe almost a solved problem, and there is little doubt but that in America, where people are in the habit of courageously taking in hand ideas thus put forward, and bringing them to a successful issue, the Old World may be even outstripped in the matter.

When applied to metal less pure, and containing sulphur and phosphorus, the ferro-manganese shows, that the carbon and phosphorus both tend to harden the steel to such an extent, that their joint presence may prevent the metal from being malleable, and capable of being drawn when hot, while rendering it liable to fracture when cold. When almost all the carbon is removed by applying the ferro-manganese, it has been found that it possessed all the malleability of phosphorus iron when worked in a heated state. On the other hand, the resistance to blows in the metal is sufficient for making good rails, provided the proportion of phosphorus is not carried too far, and care be taken that on rolling the metal, the ingot to be drawn be sufficiently large for making the bars.

In producing a soft kind of steel little carburetted or altogether free therefrom, the great problem has been solved of transforming old materials into new rails of a durability which experience has not yet been able to determine with accuracy, but varying between 50 and 100 years for ordinary traffic use.

It is at the same time evident that the less ferro-manganese is put into a bath, the greater will be the chance of obtaining a soft and decarburetted metal. Hence the necessity of using a ferro-manganese in which the manganese largely preponderates.

The unit of manganese is more costly in the rich than in the poor ferro-manganese. It will become cheaper when a larger consumption shall have stimulated a more perfect production. And, on the other hand, the success of being able to be sure of the product to be obtained, is more certainly assured.

The attempt has been made to substitute for the ferro-manganese, metallic manganese or cast manganese; it has even been attempted to produce spongy manganese, but these experiments have ended in failure.

The oxide of the manganese can only be reduced with difficulty. It easily takes the state of proto-oxide of manganese in presence of carbon or carbonic oxide, without requiring a high degree of heat. But when it is attempted to remove the remaining oxygen and produce a metallic manganese, the affinity of the carbon is not

sufficient; we must either use a degree of heat, which we have not yet been able to obtain on a large scale, or we shall have to avail ourselves of the affinity of manganese for some other material—iron for instance. Hence the necessity of alloying iron with the manganese, and thus obtaining a molten product, the reduction taking place at the temperature at which the gangue of the ore is forcibly liquefied.

It is useless to try to substitute in the place of ferro-manganese, a manganese imperfectly reduced, because the admixture of silicates in the ore would have the drawback of adding to the bath of steel a substance which absorbs with avidity oxide of iron, and the amount of slag would be increased by the substitute. Beyond this, it would be an expensive material, and uncertain in its application; the portions of the metal in which the reduction has been brought about to its full extent being but few when compared with those where the protoxide of manganese is combined with the earthy elements of the gangue.

2. Another quality of manganese which recommends the use of rich alloys, is that the alloy which is formed, between the manganese and the iron, in steel, whenever an excess of the reducing alloy is applied, imbues it with qualities of the greatest importance, and hitherto but little known. In order to call forth to their fullest extent these qualities, it will be requisite to leave 0·8 to 1 per cent. of manganese in the metal, which cannot be done without using the very richest ferro-manganese; for in default thereof we should be simply carried back to spiegeleisen. Carbon would be re-incorporated with the steel, and we should be prevented from obtaining a soft metal on the one hand and one containing phosphorus on the other.

Whenever steel be manganetic through an excess of rich ferro-manganese, the resistance to blows is increased in a striking manner. We may either allow more phosphorus to remain, or we may impart to a cheap material greater value in point of safety and durability. The conversion of old iron rails into new ones, of cast metal, will then cause the apprehensions to disappear which had been entertained, as regards the future of the new metal, in comparison with steel rails of first quality. Another quality of these new steels is that of hardening in water, which was inapplicable to soft steel entirely decarburetted (whether containing phosphorus or not), is easily obtained once more, as though the metal were carburetted and pure. Practically, this is less important than the increase of resistance to blows, but from a theoretical point of view it is a curious fact. If the carbon and phosphorus replace each other for the hardening of steel, the carbon and the manganese seem to replace each other in producing a metal capable of hardening in water.

For a long time past it has been an acknowledged fact, that manganese co-operated usefully, in puddling the better kinds of iron or puddled steel. The manganese causes the slag to be less adhesive; it retards the disappearance of carbon, and admits on the one hand of a greater attainment of purity, and on the other of the retention of part of the carbon whenever iron approaching steel is to be produced. The only difficulty arising, is that there may be too much manganese in the metallic bath, for in such an event the refining process would become a tardy and difficult one. The ferro-manganese allows the precise quantity of manganese to be apportioned, and it has thus far given the most satisfactory results.

Until now the ferro-manganese, which contains upwards of 25 per cent. manganese, has been imported into America from Europe, and the question arises whether the ironmasters of the United States will be always dependent on the Old World, for a product, which seems to be destined to play a part of such importance. The use of a similar substance adds but little to the cost of a ton of steel, and labour being dear in the United States, it seems doubtful whether the Americans will be able to produce steel at less cost than European manufacturers can do, who are familiar with this new species of metallurgy.—*The Iron Age*, New York.

It is recommended by the German ironmasters that ferro-manganese should be employed as a substitute for spiegeleisen in the Bessemer process.

At the Terrenoire Ironworks it is produced in the following manner:—

The manganese liquor produced in the manufacture of bleaching powder is precipitated by means of lime; the precipitated oxides are mixed with a necessary quantity of the purest iron ore—generally the powdered magnetic ore from Algeria, and the mixture cemented together, after the addition of 15 per cent. of pure coal dust and a little fluorspar, with bitumen. The bricks thus formed are heated in a furnace—*four dormant*—preparatory to their being transferred, still glowing, into a Siemens furnace. The end of the operation is the reduction of the metallic oxides and their fusion, both operations requiring a very high temperature.

The manganese and iron ores employed must be free from sand and clay, and the hearth of the furnace must be formed of an agglomerate of graphite. So soon as the attendant notices that the masses begin to fuse, he adds a certain quantity of spiegel-

eisen, rich in manganese. The product often contains as much as 65 per cent. of manganese.—*Deutsche Industrie Zeitung.*

FILTRATION, THE LAWS OF. M. Paul Havrez published in the *Revue Universelle des Mines*, 1874, pp. 469, 551, his investigations on the rapidity of filtration of water through sand, wool, &c., which resulted in ascertaining and measuring the influences which may modify the flow of water. The influences which are exerted in all cases of filtration, are, the pressure and temperature of the water, the thickness of the filtering medium—compression in the case of fibrous filters—the size of the grains and their mixture in the case of a filtering medium analogous to sand. The influence of obstruction, due to the dirtiness of the filter, depends on circumstances too variable to be taken into account. The delivery of a filter per square mètre per twenty-four hours is equal to 2 cubic mètres multiplied by the pressure of water in mètres, divided by the thickness of the filtering medium in mètres. An application of this formula is made to existing filter beds, including those at Southwark and at the Chelsea water-works.

The first experiments for ascertaining the influence of a head of water on the delivery led to the following results:—The delivery increases in a higher ratio than the square root of the pressure, due to the height (Torricelli's law); the delivery increases in direct ratio to the height of the column of water above the filter, admitting a previous initial delivery, due solely to the pressure of the water above the filter; the co-efficient of the increase of delivery is constant, and in the case of a filtering substance 8·662 in. (22 centimètres) thick, is equal to 0·106 pint (6 centilitres) for sand, to 0·528 pint (30 centilitres) for compressed wool, and to 0·792 pint (45 centilitres) for wool only slightly compressed.

The subsequent experiments were made with graduated transparent glass cylinders, 3·28 ft. (1 mètre) high, with the ends perfectly level, the filtering substances being kept in place by a thick double cloth tied tightly under the bottom of the tube. This apparatus presented no other obstacle to the running of the water than the layer of filtering substance; it permitted experiments to be made at all temperatures, and the thickness of the filtering medium to be measured exactly.

In these experiments sand is taken as the type of pulverulent substances; but an unexpected difficulty was encountered in the settling or partial agglomeration of the large and small grains of the unsifted sand, thus diminishing the delivery of water to one-half, one-third, and ultimately to one-fifth of its previous volume. This led to the adoption of sand—the grains of which were uniform in size—and to the discovery of the fact that, other things being equal, the resistance of filtration is constant when the sand is coarse, when the grains of fine sand are nearly of equal size, and when there is but little fine sand mixed with the coarse. From experiments in filtering through a layer of coarse sand, approximately 4 in. (10 centimètres) thick, it was found that the higher the temperature the more rapid was the delivery; and by filtering through a layer of coarse sand 11·8 in. (30 centimètres) thick, the conclusion was arrived at that the temperature exerts an influence in proportion to the thickness of the layer.

FILTER, THE SPONGY IRON. Bischof's *Patent.*—In vol. i. p. 937, article Copper, will be found some account of a process patented by Mr. Bischof for precipitating copper from its solution by the action of iron in a coarse powder. A modification of this process has been applied with much advantage in the filtration of water. In the copper process the iron was obtained from iron pyrites, by roasting it with coke in close vessels. This iron was not found to be sufficiently pure for filtering water, consequently the filtering medium is now made by reducing the iron scales obtained in the processes of manufacture, carefully avoiding the point of fusion. The peculiar properties of this spongy iron are best described by Mr. Bischof himself in a paper read by him before one of the scientific societies of Glasgow, extracts from which are given below. In vol. iii. p. 1100, article Purification of Water, will be found a description of Mr. Spencer's process of filtration by the use of the magnetic oxide of iron.

'The property of metallic iron of purifying impure water has been known for a long time. It was found that, if ships had to take in foul water, its quality materially improved by being kept in iron tanks for a sufficient length of time. Here the rolling of the ship, constantly renewing the contact between iron and water, accelerates the purifying action, which on land in a state of rest is extremely slow. Dr. Medlock first proposed, in 1857, to employ iron as a purifying medium by suspending, in a tank or reservoir containing the water to be purified, by means of iron rods passing across it, iron wire of about $\frac{1}{16}$th of an inch in diameter, loosely packed in bundles or coils, in the proportion of about 1 lb. by weight of wire to every 100 gallons of water. The water was to be left in contact with the iron wire for 24 to 48 hours.

'Dr. Medlock explains the action of iron, by supposing that it converts the nitrogenous matter and ammonia present in water into nitrous and nitric acid.

'One cubic foot of spongy iron, in the loose state, in which it is best suited for purifying water, weighs only 70 to 80 lbs.[1] It is thus evident that, weight for weight, it must offer an incomparably greater surface to the water than iron in any other form. Besides, if we bear in mind certain properties of spongy platinum—its oxidation and conversion of alcohol into acetic acid—the supposition is not far fetched, that spongy iron may also possess properties differing from those of iron which has been fused.

'I have experimentally investigated the following properties of spongy iron:—

'1. It decomposes water—even distilled water—which has been previously boiled. The decomposition of water is more energetic at an elevated temperature.

'2. It reduces nitric acid to ammonia. This was proved in the following manner:—One of Fresenius' tubulated cylinders for washing gases was filled with spongy iron, and the latter washed with pure distilled water free from ammonia. No ammonia could be detected in the wash-water by the Nessler reagent. Then a solution of saltpetre, containing 5 m. gr. of nitrogen per litre, and free from ammonia, was slowly filtered through the spongy iron at the rate of 1 volume of the fluid, equal to the volume of spongy iron in the filter, in 3 hours. The filtrate contained 1·4 m. gr. of nitrogen per litre in the state of ammonia, or 28 per cent. of the equivalent quantity of nitric acid contained in the liquid.

'3. From the fact that organic nitrogen and albuminoid ammonia are always much reduced after filtration through spongy iron, the conclusion must be drawn that spongy iron is capable of decomposing nitrogenous organic matter. Also the organic carbon, as will be shown by the analytical results on another page, is very considerably reduced by filtration through spongy iron.

'4. A minute, almost constant quantity of iron, about 10 m. gr. per litre, is dissolved by means of the carbonic acid contained in water, when filtering it through spongy iron, forming ferrous carbonate. The latter is very soon oxidised and precipitated, and it may then be so completely separated from water by mechanical filtration through paper or sand, or by allowing it to subside, that potassium ferricyanide no longer indicates a trace of it.

'If the water containing iron in solution be made to pass through a layer of finely divided marble, or ordinary limestone, or animal charcoal, the iron is retained at once as ferric-hydrate.

'5. The purification of water increases slightly, for some five or six hours after the filtration through spongy iron has been completed.

'6. If the iron be prevented from dissolving by adding to the water before filtration a minute quantity of sodium carbonate, the purifying power of spongy iron is considerably diminished.

'7. The purifying action of spongy iron on organic matter is more energetic in hot weather than in winter, when the temperature of the water is frequently below the point (5° or 8° C.) at which fermentation ceases almost completely. This appears to confirm my opinion that the action of spongy iron on impure water is twofold, namely, chemical and mechanical. The chemical action is clearly indicated by the decomposition of water. The readiest explanation for the decomposition of water, is the intimate contact between electro-positive and electro-negative bodies, such as metallic iron and carbon, or even metallic iron and any ferric-oxide which has escaped reduction, or which has been re-oxidised by exposure to air or water; and it may well be supposed that, consequent to the galvanic current thus produced, the atmospheric oxygen dissolved in water is ozonised, and caused to act as a powerful oxidising agent on organic matter. I am driven to this conclusion from the results of a large number of analyses made before, and after, filtration through spongy iron, which, notwithstanding the fact of the reduction of nitrates and nitrites, also clearly indicate an oxidising action shown by the increase of nitrates after filtration. This increase is usually very considerable. The quantity of albuminoid ammonia, as already explained, is considerably reduced after filtration. There is no fixed rule for the increase or decrease of free ammonia before and after filtration, which appears to depend upon the predominance of certain agencies.

'The purifying action of the iron, which is dissolved, may either consist chemically in the iron being reduced by agency of organic impurities, whilst in some low state of oxidation to a still lower state—the organic impurities thus becoming oxidised; the iron thus reduced may again be oxidised either by means of the oxygen dissolved in water, or the oxygen resulting from the decomposition of water; or the action of the dissolved iron may be either wholly or partly mechanical, consisting in a surface

[1] The spongy iron at that time used to contain a considerable excess of coke. It is now made with less coke, hence its specific gravity has been somewhat increased.

attraction of dissolved organic matter, by the flocculent precipitate of ferric hydrate, formed by oxidation of the ferrous carbonate, similar to the action of the precipitated calcium carbonate in CLARK'S softening process, of alumina and other bodies. That the ferric hydrate has partly, at least, such a mechanical action, becomes probable from the fact that if its precipitation be hurried by boiling, the purifying action is lessened.

'There is, besides organic matter, another dangerous substance not unfrequently met with in water, viz. lead.

'Water containing lead in solution was filtered through one of the spongy iron filters. In the filtered water no trace of a colouring could be detected, and even after concentration to $\frac{1}{10}$th of its volume, the presence of lead could not be detected. This result was to be expected from the well-known fact, that lead salts are precipitated by metallic iron, and that spongy iron is a much more energetic precipitant than iron in other forms. This property, too, is an important and welcome addition to the employment of spongy iron for purifying water.

'Experiments continued for upwards of eight months have further proved that spongy iron is capable of considerably reducing the hardness of water, in some cases up to 50 per cent., whilst the softening action of animal charcoal ceased after a fortnight.'

With a view to having a filtering material of an entirely *inorganic* nature, Mr. BISCHOF originally proposed limestone, in preference to animal charcoal, for accelerating the precipitation of the ferrous carbonate before referred to. Animal charcoal appeared objectionable, as it is well known that it is apt to undergo decomposition after a certain variable time—not unfrequently after even only three months' use—when it actually contaminates the water. Practical experiments have, however, demonstrated that animal charcoal may be safely employed *in combination with spongy iron*, a fact which is readily explained by the well-known antiseptic properties of the ferric hydrate which is deposited within the pores of the charcoal. In reference to this interesting phenomenon see, amongst other publications, the *Handwörterbuch der Chemie*, vol. ii. part iii. p. 625, by LIEBIG, POGGENDORFF, and WÖHLER; in fact, it is known to every one from the destructive action of rust-stains, which are oxides of iron, upon such highly indestructible organic bodies as the textile fabrics.

The employment of animal charcoal instead of limestone offers, under these circumstances, several advantages. It appears to be able to decompose certain organic bodies, upon which spongy iron has little or no action, and *vice versâ*, and it retains free ammonia to a much greater extent than limestone.

One of the most important questions in regard to filtering materials is, how long will they remain active, and when do they require renewal? Filters have been in use upwards of twelve months without changing the spongy iron. The unexpected result was thus arrived at, that the purifying action *increases* for many months after starting a filter, owing undoubtedly to the increased formation of ferric hydrate. However, as some waters contain large quantities of suspended organic and other impurities, and as the filtering materials are cheap and easily re-charged by the user, it is recommended to re-charge the filter every *six* months.[1]

The construction of the spongy iron filter has of late been very considerably improved by a simple and effective arrangement, which regulates the rate at which the water passes through the filter. No other filter is provided with any such perfect arrangement. The water in most filters passes through at first too freely, and when the filtering materials become gradually choked, too slowly, or not at all. The spongy iron filter, on the other hand, may, practically speaking, by aid of the regulator, be made to filter with little care at always the same rate.

The following is contained in a letter received from Professor BISCHOF, dated Glasgow, June 26, 1874:—

'I finished yesterday my monthly experiment with the undermentioned filters, and herewith communicate the result to you, which is very remarkable, showing a distinct improvement in the action of the spongy iron, which beyond doubt is partially due to the continued formation of hydrated peroxide of iron, and partially to the warm weather. The animal charcoal and the limestone in the spongy iron filters had been in use six months, the spongy iron at least twelve months. The animal charcoal which was employed for filtration *without* spongy iron, under other like circumstances, had been in use three months. The carbon block measured 4 in. in diameter and 4 in. in height. It had been in use for thirteen days only, and filtered one gallon in *nine hours*.'

[1] Further practical working has proved that with water of equal quality to the average London water, and when the filter is supplied from a cistern in which the water is allowed to free itself of impurities in *suspension* by settlement, the spongy iron need only be replaced once in every twelve months' use of filter.

	Organic Carbon		Organic Nitrogen		Free Ammonia	
	Found[1]	[2]	Found[1]	[2]	Found[1]	[2]
Unfiltered diluted sewage	·341	100	·086	100	·025	100
Same filtered through a carbon block	·328	96·2	·083	96·5	·009	36
Same filtered through animal charcoal only	·285	83·5	·033	38·4	·009	36
Same filtered through spongy iron and limestone	·048	14·1	·023	26·7	·007	28
Same filtered through spongy iron and charcoal	·029	8·5	·003	3·5	·004	16

The Average Composition of Thames Water, before and after Filtration through Spongy Iron, as given in the Sixth Report of the Royal Commission on Rivers Pollution.

Description	Dissolved Matters					
	Total solid Impurity	Organic Carbon	Organic Nitrogen	Ammonia	Nitrogen, as Nitrates and Nitrites	Total combined Nitrogen
As delivered from Chelsea Waterworks	28·04	·198	·042	·0009	·177	·220
The same water filtered through spongy iron	16·8	·069	·018	·019	·018	·049
The mean of the 14th and 15th samples taken after the spongy iron filter had been in operation in the Rivers Commission laboratory for upwards of eight months.[3]						
As supplied from waterworks	24·47	·170	·055	·001	·098	·154
After filtration through spongy iron	14·26	·083	·016	0	0	·016

Description	Dissolved Matters					
	Previous Sewage or Animal Contamination	Chlorine	Hardness: Temporary	Hardness: Permanent	Hardness: Total	No. of Samples analysed
As delivered from Chelsea Waterworks	1,464	2·01	15·5	6·2	21·7	15
The same water filtered through spongy iron	177	2·00	6·8	4·9	11·7	15
The mean of the 14th and 15th samples taken after the spongy iron filters had been in operation in the Rivers Commission laboratory for upwards of eight months.[3]					Analysis of the 15th sample	
As supplied from waterworks	675	1·95	—	—	19·1	—
After filtration through spongy iron	0	1·95	—	—	9·6	—

[1] In 100,000 parts of water.

[2] These columns show the percentage of respectively organic carbon, organic nitrogen, and free ammonia, still contained in the filtered water, the quantity in the unfiltered water [illegible] equal to 100.

[3] The figures demonstrate that the purifying action of spongy iron, if at all altered, had been *increased* as regards the most important impurities in water, viz., nitrogenous matter and hardness.

Dr. E. Frankland, in his Report to the Registrar-General, December 31, 1875, says:—

'To illustrate the improvement of Thames water by domestic filtration, I have analysed a sample of the Grand Junction Company's water after filtration. The results are as follows:—

Grand Junction. December 7.

	As supplied	Filtered through Spongy Iron and Animal Charcoal
Temperature in Centigrade degrees	8·0	—
Total solid impurity	32·46	19·84
Organic carbon	·139	·028
Organic nitrogen	·041	·013
Ammonia	·002	·130
Nitrogen, as nitrates and nitrites	·340	·093
Total combined nitrogen	·383	·203
Previous sewage or animal contamination, *estimated*	3,100	1,860
Chlorine	1·55	1·57
Total hardness	22·0	16·1

'These results show not only the removal of all turbidity, but a reduction of total solid impurity from 32 to 20 parts, a diminution of hardness from 22 to 16°, and a removal of more than three-fourths of the organic matter.

The Bischof filter is shown in section, *fig.* 2343, A A being the water to be filtered, C the spongy iron, and D the mixture of charcoal and limestone, B being the purified water. *Fig.* 2344 shows the lower section, A, as separated from its case containing the

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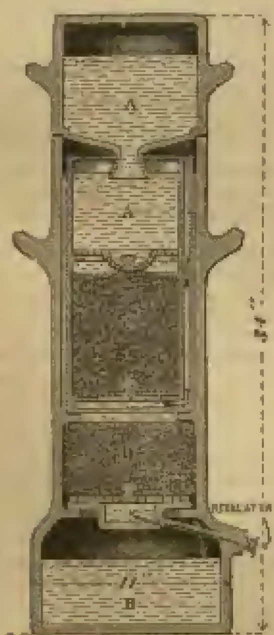
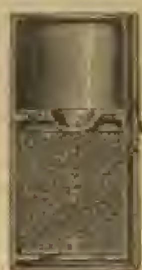


2344



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filtering material. *Fig.* 2345 shows the construction of the bed plate at the bottom of D, and the attachment of the regulator, which is shown detached in *fig.* 2346.

Fig. 2347 shows the top of the filter, a bottle to hold the supply of water, which, when filled, is to be inverted as shown in *fig.* 2343 at A.

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DIRECTIONS FOR USE.

a. Instructions for starting the Filter as delivered charged with the Filtering Materials.—(1) Take out the paper underneath the inner case and underneath the perforated lid on the top of the inner case, and attach the stop-cock at the bottom of the filter. (2) Remove the cap, A, screwed over mouth of regulator, and place the opening over some vessel, or sink, to receive the waste water. (3) Fill the filter and let the water run off until bright and free from taste. (4) Replace the cap of regulator.

b. Instructions for Filtering Water.—(1) Fill the spongy iron vessel with water; or the latter may be more conveniently supplied by means of the bottles, B, which are specially constructed for the purpose to be inverted into the filter; or a constant supply may be had by employing a ball-cock with glass ball. (2) When the yield of the water diminishes, unscrew the regulator cap, A; if water runs out freely from the opening, the regulator must be cleaned by passing up the tube the small brush supplied with each filter; or, if the water does not run out freely, loosen the spongy iron by piercing with a pointed wire or knitting pin.

No spongy iron filter need be recharged, under ordinary circumstances, in less than about twelve months. The filter should be kept constantly full. Draw off filtered water daily. The more the filter is used, the brighter will be the filtered water.

c. Instructions for Re-charging the Filter.—(1) Empty and wash the cases. (2) Fill the prepared sand into the outer case. (3) Place the inner case into a filter, fill with water up to the rim on which the perforated cover rests, and charge with spongy iron. (4) Wash the filter.

Since this article was written, animal charcoal has been abandoned, and the following notice issued:—

'The property, which animal charcoal possesses in a high degree, of favouring the growth of the low forms of organic life is a serious drawback to its use as a filtering medium for potable waters.'—*Sixth Report of the Royal Commission on Rivers Pollution*, p. 220.

'In consequence of this startling statement, emanating from the highest authority in the kingdom, the SPONGY IRON WATER PURIFYING COMPANY, acting under the guidance of Professor G. BISCHOF, have directed their attention to discovering the best means of replacing the animal charcoal hitherto used in their filters in connection with spongy iron, by an *inorganic* substance, which is free from the grave objection quoted above. They feel much satisfaction in informing their customers that they have succeeded in discovering such a substitute, and that in future, unless otherwise desired, their filters will be supplied charged with spongy (metallic) iron and a prepared sand. The latter is a mixture of carefully selected and washed sand, and of pyrolusite, a mineral charged highly with oxygen, which it is capable of transferring largely to various impurities occurring in water, thus rendering them harmless. Pyrolusite is also *by itself* a valuable purifying medium for water. The other constituent of pyrolusite, manganese, occurs in the celebrated waters of Spa and Pyrmont.'

FIRE BRICKS. The production of a brick which shall resist the action of a very high temperature is a matter of considerable difficulty. The questions involved have not yet received a satisfactory answer. It is quite certain that we cannot in all cases depend upon the refractory property of any natural clay. Even fire-clays having the same chemical composition are found to act differently under slightly different conditions. This proves that the physical characteristics of a brick are nearly, if not quite, as important as its chemical composition.

In discussing a refractory material in a given locality, there is to be taken into account—first, the clay and other materials to be had; second, the ore or metal to be

treated; third, the fuel to be used; and fourth, the foreign substances in the gangue of the ore or metal. Whether to use one clay, or a mixture of calcined or raw clay, must be determined by direct experiment, and then the size of the grains of the mixture for the given use must be determined, for each substance is more or less refractory, according as it is coarse or fine. Thus, in Belgium, a porous material with a large grain is used for blast-furnace bricks, but a fine material with a close grain for coke furnace bricks, the chemical composition being the same in both cases. It must then be ascertained whether the mixture contracts or expands, for there are clays that contract or expand in a variety of degrees between one-thirty-second and one-eighth. It is not sufficient to have a good material, for almost as much depends on its manipulation as on the material itself. To temper properly, long exposure to the action of the air is often necessary, and where artificial heat is required, the clay and the manufactured article should both be dried gradually and uniformly. It must be fired evenly, and the temperature slowly raised to the proper point. If it is to be used as ganisters, it must be equally moist throughout, so as to dry uniformly, and not so wet as to cause it to crack in drying, or so dry as to prevent its binding. The brick, once made, should be kept from dampness, as it is porous, and likely to absorb moisture. The bricks should be heated before being used in the furnace, and put in as hot as it is possible to handle them. If the furnace is in blast, this rule has a special force. If it is to be put in blast at once, especially with silica bricks, the temperature should be as high as the hand can bear. If the furnace is to be a long time standing, this precaution is not necessary, but in the two last cases the furnace must be dried very carefully and slowly. No brick which has been dressed should ever have the dressed face exposed to the flame. Without the observation of these precautions, a really good brick may have a very bad result. It is too much the habit to be in a hurry to get results, and this has led some blast-furnace managers to boast that steam was issuing from the top of their furnace while cast iron was being tapped from the bottom; but under such management we never hear of long endurance.

It is well known that the alkalies tend to make a brick fusible, but there is considerable difference of opinion as to the quantity of alkali which must be present in the clay to destroy its fire-resisting property. Mr. Snelus states positively that 1 per cent. of alkalies in an otherwise good material makes it too fusible to withstand high temperatures. Mr. Riley states that he has found bricks containing 2·73 of potash to resist the greatest heat of a Siemens-Martin furnace. It is probable that in the special cases alluded to, the peculiarities were owing to the physical condition and mechanical association of elements.

Lime alone is completely infusible; but small quantities in a clay make a brick fusible at high temperatures. One per cent. of it, with silica, is stated to make the most infusible brick known. Magnesia, in small quantities, makes the clay fusible. In very large quantities it is very refractory.

Bischoff has found that 20 per cent. of magnesia, 28 of lime, 47·1 of potash, or 40 per cent. of iron, had exactly the same effect in making the clays fusible, and that when 4 and 2 of the different bases were used, the relation was striking, and in about the same order. The quantity of other substances necessary to make a fire-clay fusible depends upon the quantity of silica present. While the predominance of any one element will materially affect the nature of the materials, the way in which the different ingredients are grouped together affects the nature of the brick more directly than its composition, and frequently the mechanical and molecular arrangement of the particles determines its value more especially than its chemical character.

Oxide of iron, in the absence of alkalies, may be present in small quantities without seriously affecting a fire-clay, unless the bricks made of it are to be used for melting steel. If alkalies are present, any proportion of iron would render such a clay worthless. If no silica at all is present, 5 or 6 per cent. of oxide of iron may not damage it. In a silica brick, 2 to 3 per cent. of oxide of iron makes the brick worthless. If the iron was always certain to remain in the state of a sesquioxide, a large percentage would do no injury; but some of the sesquioxide is certain to become reduced to protoxide in the presence of reducing gases, and the result is a very fusible compound in the presence of silica.

There is another deleterious effect of iron in fire-brick: its deoxidation is produced, not at a high heat, but at a comparatively low one.

The good qualities of a fire-brick are—(1) uniformity; (2) regularity of shape, and the power to retain it under all circumstances, which involves perfect unity of composition; (3) strength to resist the different pressures required under different circumstances. No material yet manufactured fulfils all these conditions; but there seems to be no reason why a material should not be made which will fulfil most of them. The metallurgical world is nearly agreed that the refractory material of the future must be made artificially, and that it is hopeless to look for it among natural pro-

ducts. Hence we find that the bricks which are made from the waste materials of the china clay works possess advantages of their own. No brick can come up to the required standard of infusibility which contains 5 per cent. of iron, or 3 per cent. of alkalies or alkaline earths. The most infusible brick known, which in the roof of a SIEMENS-MARTIN furnace will resist the intense heat during 240 charges, and then wear out by abrasion, when brought in contact with metals, oxides, and alkalies in a spiegeleisen cupola, will not stand twenty-five heats. Different furnaces, and different parts of the same furnace, must, therefore, be treated differently. If silica makes the best roof, it makes the worst hearth. Alumina, when present in very large quantities, even in the presence of a small amount of silica, makes compounds which are almost infusible, so that it should be used for the fire bridges and hearths, and not put into the roof, where its tendency to contract would endanger the structure of the furnace.

Too little attention has been given to the abrasive power of coal-dust and ashes carried by the draft, in gradually cutting and fluxing away the parts of a furnace exposed to its action, and many qualities of brick which are ordinarily infusible owe their small power of resistance to the mechanical erosion of the dust of the fuel used. A brick to be exposed to such action should always be tried by placing it on the bridge of the furnace where it is to be used. The destructive effects of this agency seem to be even greater than those of long-continued heat.

A good fire-brick should not only resist high temperatures, but withstand any sudden changes of temperature without alteration, such as crushing, splitting, &c., and it should not undergo any change of form under the influence of the greatest heat. In general, it may be said that bricks which have undergone a very high temperature in the manufacture are less likely to contract afterwards. Shrinkage is generally due to insufficient burning, and generally occurs in aluminous bricks. Siliceous bricks have, on the contrary, a tendency to expand under the influence of intense heat. In the steel furnaces where fire-bricks are used, provision must be made for slackening the tie rods when the fire is being raised, and tightening them when it is being cooled.

The crushing weight of a good ordinary fire-brick, cold, is from 600 to 1,000 lb., but some of the best have been known to resist as much as 3,000 lb. to the square inch. To ensure the safety of a blast furnace and the success of the process of smelting iron, the bricks of which it is built should not only retain their power of resistance, but should not undergo any change of form or soften materially under long-continued heat, and at the highest possible temperature should support more than double the strain required without attention. In the walls of the fire-place those bricks will be best which are dense, and contain an excess of silica. In the hearth they should contain an excess of alumina. In the arch they should be nearly pure silica, alumina, or magnesia. Splintering takes place when silicate bricks are made of impure mixtures, and from imperfect burning. Bricks which are liable to splinter are generally cross-grained and dense, with a smooth conchoidal fracture.

The conclusions to which experiment and experience have led us, are that a brick which is good for the cupola would be worthless for the reverberatory furnace; that which answers well for iron would generally be worthless for zinc, and a crucible which is excellent for steel cannot be used for brass. All investigations appear to show that we should look for artificial, and not for natural compounds, if we hope to secure fire-bricks suited for all the different processes for which they are employed, and that when we have made a mixture which answers it well, we are then to analyse and examine it in order to reproduce it. Failure in this special purpose is very often owing to the wrong application of good materials, rather than the fault in the materials themselves.

FIRES, COLOURED. Green, red, violet. See PYROTECHNY.

FLAX. (Vol. ii. p. 404.) We supplement that elaborate article by giving the importations of the last two years.

Imported in 1876.

Dressed.

	Cwt.	£
From Russia	4,207	21,304
" Germany	9,742	26,808
" Holland	4,874	19,847
" Belgium	27,819	137,732
" France	4,131	14,648
" other Countries	717	1,678
	51,490	222,012

Roughed or Undressed

	Cwt.	£
From Russia	962,079	2,176,199
„ Germany	80,073	185,201
„ Holland	153,935	503,657
„ Belgium	200,9[illegible]	793,072
„ France	8,773	19,[illegible]
„ other Countries	7,442	14,380
	1,413,245	3,662,061

Tow or Codilla of.

	Cwt.	£
From Russia	235,658	431,856
„ Germany	8,040	14,886
„ Holland	16,542	27,843
„ Belgium	47,564	50,984
„ other Countries	1,371	1,764
	309,205	527,333

The importations of 1876 were as follows:—

Flax—Dressed, Undressed, and Tow or Codilla of.

	Cwt.	£
From Russia	1,017,899	2,330,683
„ Germany	43,271	96,312
„ Holland	98,889	278,000
„ Belgium	231,414	799,822
„ other Countries	13,185	23,021
	1,404,661	3,537,448

FLINT. (Vol. ii. p. 457.) The process described in the volume referred to is that adopted in a French manufactory. The following is furnished by a gentleman well acquainted with the processes as carried on at Brandon:—

Flint has been valuable from the earliest times as a 'fire-stone,' and was dug for this purpose and fashioned into convenient shaped pieces called 'strike-a-lights.' The present writer has shown that in this strike-a-light manufacture we have the connecting link between gun-flints on the one hand and the neolithic, or newer stone-age, on the other. The strike-a-lights used before the introduction of metal are identical with those made even at the present day at Brandon, in Suffolk. The introduction of the flint-lock gun gave a fresh impetus to the flint trade, and the same writer has shown that the earliest gun-flints were merely small strike-a-lights.

The only place where, with very trifling exceptions, gun-flints are now manufactured is at Brandon, from which place about 80,000 are still sent away weekly.

The flints are dug in the neighbourhood of the town at Lingheath, but they have been obtained from many other places in the vicinity, and old pits dating from the stone-age are still traceable, and have been explored. The present writer has shown that the method of mining and the tools used are merely improvements upon the stone-age methods. Five beds of flint are found, named respectively *horns*, *toppings*, *upper-crusts*, *wall-stone*, and *floor-stone*, each of which possesses distinctive features, the last and lowest being the bed which yields the best flint. Each workman, called a stone-digger, sinks his own pit down to the floor-stone, leaving stages at every 4 ft. The pits are sometimes 40 ft. in depth. The workman then drives a gallery, called a *burrow*, underneath the stone, which he quarries down with a one-sided pick. All the chalk and stone are carried to the surface by hand. The length of this first burrow is about 9 yards, the width 2 yards, and the height about 2 ft. 6 in. At the further end the digger clears away a semicircular space called a *draw*, about 3 yards each way. A side-burrow is then driven curvilinearly from near the beginning of the main-burrow, so as to catch the end of the draw. Halfway down the side-burrow a *drawing-burrow* is carried into the main-burrow, and the intermediate space cleared out. Similar side- and drawing-burrows are then made from the other side of the main burrow. Another main-burrow is then driven at right angles to the former one, which, with its dependants, serves as a receptacle for the chalk. The whole process is then repeated, and in this manner the pit is worked all round. This peculiar process is only a development of the neolithic mode of working; just as the pick is only an iron copy of the deer antler tool used by the old people.

The stone is carried daily to the pit's mouth, stacked in heaps, and covered with

boughs to protect it from the weather, a slight exposure to which would render the flints unfit for the flint-knapper's use. The flint is sold by the one-horse load, called a *jag*, and carted to the knappers' shops.

An average jag of good flint was found by the writer to yield only 18 per cent. in gun-flints. It weighed about 13 cwt. and yielded 10,850 gun-flints. Besides this there were 270 building stones, which made the gross waste 53 per cent. of the whole.

The best stone has a thin hard coat on the upper surface, and a thick soft coat on the lower one: it should be quite black, homogeneous, and without flaws. These qualities can only be depended upon in floor-stone, and this was known as well to the prehistoric workers as to those of the present day.

The stone is ready for knapping as soon as it is dry. The knapper, sitting upon a three-legged stool, and wearing a leather apron, and a pad of leather called the *knee-piece*, upon his left thigh, takes a block of stone, which weighs from ½ cwt. to 3 cwt., rests it upon his knee-piece, and taps its upper coat with a heavy iron hammer. By the sound he tells whether the flint is sound, whether it is of good texture, whether the coat is single or double, and at what point and with what force he must strike it to split it straight across. A blow is then struck from the elbow and the flint breaks. In this way the stone is reduced into convenient sized angular pieces called *quarters*, the process being called *quartering*. The quarters average about 6 in. cube.

The next and most difficult process is *flaking*, or the driving off of flakes at a single blow, of a given width and thickness, with two ribs running down them. In this the Brandon knappers excel the prehistoric workmen, but the process is so delicate that few attain to great proficiency; some indeed are never able to flake profitably. The tool at present in use is a square steel hammer tapering at both ends to a small face, and fitted with a thin handle. The size varies according to the size of the quarter. With a hammer of a given weight there is a maximum length and thickness of flake which cannot be exceeded. For each flake there are—(1) a certain spot upon which the blow must fall, (2) a certain angle at which the hammer must strike, and (3) a certain weight of blow. Miscalculation in any one of these things results in an imperfect flake, and though every flake struck requires this calculation, so skilful are the best Brandon workmen that the writer has seen them work for hours without a failure, and so rapidly, that the sound of the flake falling into the tub, into which it is thrown, is heard simultaneously with that of the blow which dislodges the succeeding flake. A good flaker will make from 7,000 to 10,000 flakes per day of 12 hours. The flaker sits on the same stool on which the stone is quartered, rests the quarter against the knee-piece, so that a corner touches his knee and a flat face faces his right hand. The blow is given from the elbow, and the force is generally merely the momentum acquired by the hammer in falling from 3 to 6 in. It must so fall that only one-half of the hammer face strikes the stone, and a flake is driven off the length of the quarter. The first flake evidently has only one rib (the corner of the quarter) running down it. A flat surface is thus left. The next blow is given a little to the left, and the flake flies off with two ribs. This process is continued until the quarter is too small to yield good flakes. The resulting piece, known as a core, is then slightly trimmed, and forms a building stone or *builder*. The flakes and waste are thrown into small tubs, arranged about the flaker according to their quality. Prior to the introduction of the square-faced hammer an oval hammer was used. This is still in use for rough purposes, and is called the *English hammer* to distinguish it from the other, which was introduced from France. The English hammer is exactly like the stone-age flaker. All flaking hammers have a very small 'eye' for the insertion of the handle, the object being to attain the maximum of weight with the minimum of size. The handle is, consequently, too slender to be used in striking heavy blows; but this is of no importance, since flaking is performed by a very slight blow. The stone-flaking hammers have precisely similar eyes.

The next process is the fashioning of gun-flints from the flakes, and is called *knapping*. Knapping is performed upon a block made from the bole of an elm tree, about 2 ft. high and 3 ft. in diameter. In this is inserted an iron *stake*, having a flat edge upon which the flake is rested. The stake is fixed into the block by triangular strips of leather, but it does not reach the wood beneath. The knapping hammer is a light square-edged tool made from an old 6-in. flat file. The flake is laid back downwards on the stake at a certain angle, and then struck squarely with the hammer, the blow being slight, rebounding, and delivered entirely by the wrist. The blow cuts the flake across, leaving a square edge sloping towards the back. The flake is then turned in a direction opposite to that of the hands of a watch, and the side of the flake trimmed square. Again turning in the same direction, the flake is once more cut across, and the other side is then trimmed, thus completing the gun-flint. The cut sides of the flake form the sides, and the edges of the flake the edge and heel of the gun-flint. So rapidly is this action performed, that an average work-

man will knap 3,000 gun-flints in twelve hours. Two or three flints of different sizes are generally made from a single flake. At present only ten kinds of gun-flints are made, namely second, common and grey muskets, second carbines, second and common horse pistols, second singles, and second doubles; but before the introduction of percussion caps 32 different sorts were in use. The gun-flints are made entirely without measurement, and the skill with which they are made is very remarkable. The French knapping-hammer is a steel disc known as a *roulette*, but it is never used in England. About 80,000 gun-flints are sent away from Brandon every week, their ultimate destination being Russia, West Africa, and South America.

There can be little doubt that the Brandon industry is a lineal descendant of the newer stone-age, as is shown by the following facts: (1) the peculiar method of mining is the same, (2) the pick is a metal copy of the old deer-horn pick, (3) the flaking-hammers are like the old stone tools, (4) some of the strike-a-lights now manufactured are precisely like the ancient tools known as 'scrapers.' The modern gun-flint is directly derived from the strike-a-light, and series of specimens can be formed showing the gradual change of the one into the other.

Since the discoveries of the flint implements of the 'Older Stone Age,' vol. ii. p. 460, the question of the contemporaneity of man with the extinct animals has been abundantly proved, more especially by the discovery of drawings of those animals upon their own bones in one English and several French caves. The opinion is also gaining ground that these palæolithic men were driven from our land by the advent of ice during the glacial period. Many facts point in this direction, and Mr. BELT has tried to show that the implement-bearing beds of Hoxne underlie glacial clay. Mr. R. H. TIDDEMAN has found a human bone beneath glacial clay in the Victoria Cave at Settle, M. RUTIMEYER has found basket-work in the inter-glacial lignites of Switzerland, Prof. WHITNEY has discovered human bones beneath glacial deposits in California, the writer has found implements in brick-earths older than the Chalky Boulder Clay, near Brandon, and Mr. PENGELLY has shown the great probability of the oldest tools in Kent's Cavern being pre-glacial.

The manufacture is still carried on to a limited extent at Brandon, in Suffolk; about 80,000 gun-flints are sent away weekly. In 1876 there were 21 workmen engaged in flint-working at Brandon. An elaborately illustrated work upon the subject is in preparation; it will form one of the *Memoirs of the Geological Survey*.—S. B. J. S.

FLUORESCEINE is one of the derivatives of resorcin. See RESORCIN. If resorcin is heated to 195° C. with anhydrous phthalic acid we obtain fluoresceine. It crystallises from alcohol in small deep brown crystals. With ammonia it yields a red solution, which, even when very dilute, displays a magnificent green fluorescence.

Fluoresceine dyes wool and silk a fine yellow without a mordant.—CROOKES'S *Handbook on Dyeing*.

	1	2	3	4	Mean
SiO^2 . . .	·06	—	—	·05	·08
Al^2O^3 . . .	·65	·65	—	—	·65
Fe^2O^3 . . .	67·43	67·50	67·32	67·42	67·42
FeO . . .	15 68	15·62	—	—	15·65
ZnO . . .	6·79	6 81	6·76	6·75	6·78
MnO . . .	9 71	9·47	9·51	9·44	9·53
	100·31	100·16	99·07	99·99	100·12

This gives from the mean of the four analyses:—

	Metals	Oxygen	
Al^2	·35	·30	20·53
Fe^2	47·19	20·23	
Fe	12·17	3·48	6·97
Zn	5·44	1·34	
Mn	7·38	2·15	

The results of these analyses give in both cases a ratio very nearly corresponding to that of spinel, notwithstanding the great differences in the relative amounts of iron, zinc, and manganese.—*The American Journal of Science and Arts*, September 1876.

FRANKLINITE. (See vol. ii. p. 485.) The following analyses of Franklinite are by Mr. GEORGE H. SEYMS, and were made in the Sheffield Laboratory, Yale College, U.S.

The experiments were made to determine whether the variations in the amount of iron in the ore supported its relation to the spinel group. The first experiments

were made on perfectly formed crystals in a matrix of limestone from Mine Hill, Sussex County, New Jersey, U.S. The analyses gave results which may be best expressed as follows:—

	1	2	Mean
SiO^2	·17	·17	·17
Fe^2O^4	63·42	63·38	63·40
Mn^2O^3	4·44	4·44	4·44
MnO	10·39	10·53	10·46
ZnO	23·11	23·12	23·11
	101·53	101·64	101·58

The relations of the metals to the oxygen, taking the mean of the two analyses, are given in the subjoined statement:—

	Metals	Oxygen	
Fe^2	44·38	19·02	20·37
Mn^2	3·09	1·35	
Mn	8·10	2·36	0·92
Zn	18·55	4·56	

The following analyses were made on a sample taken from an aggregation of imperfect crystals from Sterling Hill, New Jersey. While the crystals in the former case were but feebly magnetic, these were strongly so, though they showed no signs of magnetite as an admixture.

FRAY-BENTOS GUANO. See GUANO, FRAY-BENTOS.

FREEZING. See vol. ii. p. 486, the article FREEZING, in which a table for frigorific mixtures has been given.

M. WITZ has stated to the *Académie des Sciences* that by a mixture in equal proportions of snow and hydrochloric acid, previously cooled to $-18°$ Cent., a degree of cold may be produced by which mercury may be readily frozen. See REFRIGERATION.

FRIEDELITE. A hydrated silicate of oxide of manganese. It is translucent, and in thin layers transparent, exhibits powerful double refraction with a negative axis, colour rose-carmine, hardness 4·75, density 3·07. It consists of—

Silica	36·12
Oxide of manganese	53·05
Magnesia and lime	2·96
Water	7·87

It is found in the Pyrenees.—E. BERTRAND, *Comptes Rendus*, lxxxii.

FUCHSINE, DETECTION OF, IN WINES. See WINES.

FUEL. (*Combustible*, French; *Das Brennmaterial*, German.) Professor H. FRITZ, of Zurich, has given the following table, showing the difference between the theoretical and effective heating power of various kinds of fuel. The table gives the number of pounds of water evaporated by one pound of fuel:—

Heating Power.

Fuel	Theoretical	In Steam Boilers	In Open Boilers
Petroleum	16·30	10–14	—
Anthracite	12·46	—	—
Coal	11·51	5·2–8	5·2
Charcoal	10·77	6–6·75	3·7
Coke	9–10·6	5 - 8	—
Brown coal	7·7	2·2–5·5	1·5–2·3
Peat	5·5–7·4	2·5–5	1·7–2·3
Wood	4·3–5·6	2·5–3·75	1·85–2·1
Straw	3·0	1·86–1·92	—

A series of experiments convinced Mr. THOMPSON that, on the average, only 47 per cent. of the theoretical heating power of the fuel is utilised, the 53 per cent. being

lost through imperfect combustion, radiation, and other causes.—*Journal of Applied Science*, August 1, 1876; *Journal of Franklin Institute*, September 1876.

FUEL, PRESSED. The following description of the LOISEAU PRESSED FUEL COMPANY'S works at Port Richmond will be found to be of considerable interest.

The grounds on which are erected the works of the LOISEAU PRESSED FUEL COMPANY belong to the PHILADELPHIA AND READING RAILROAD COMPANY, and have been leased for years. All the coal dust made at the wharves at Port Richmond during the same number of years has been secured by contract. When the works are started, if the supply at Port Richmond is not sufficient, additional quantities, as required, will be shipped from the coal regions.

The property consists of two lots, each 200 ft. by 275 ft., divided by Neff Street, having a front of 400 ft. on Bath Street, E., and 275 on Linden Street, N., and on Toronto Street, S. The buildings are erected at the S.W. corner of Bath and Linden. Their length on Bath Street is 128 ft., and on Linden 275 ft. They are seven in number.

1. Clay house, a frame building, one story, 75 ft. long, 22 ft. wide. 2. Engine and boiler house, two-story brick construction, 53 ft. long, 29 ft. wide. 3. Press building, two-story frame building, 51 ft. long, 40 ft. wide. 4. Drying oven, brick construction, 80 ft. long, 14 ft. wide, 20 ft. high, covered with a substantial shed, 108 ft. long, 38 ft. wide, 40 ft. high. 5. Waterproofing building, two-story brick, 40 ft. long, 40 ft. wide. 6. Coal pockets, frame construction, 100 ft. long, 16 ft. wide, 150 tons capacity. 7. Office, two-story frame, 26 ft. long, 14 ft. wide.

A quantity of 12,000 tons of coal dust is on hand, covering almost a whole square. From the pile of coal dust starts a double railroad track, leading to the foot of an inclined plane 100 ft. long. Plane track switches and curves, consists of sections of PETELER portable railroad track. The coal dust is hoisted, inside dumping carts, into the press building, and dumped on a covered platform, under which is a wire cloth sieve or screen, one inch mesh. This screen receives from the hoisting engine a rapid to-and-fro motion, and screens the coal, delivering the dust under a chain elevator, which raises and discharges the said dust into a coal bin, having a capacity of five tons. The large lumps of coal are removed from the screen and thrown into a small chute, through which it is discharged in the boiler house.

Alongside of the inclined plane is the clay house, fronting 74 ft. on Bath Street. The capacity for storing is 300 tons. The clay is dried in a kind of core oven, and by means of a platform elevator is taken to a large room, forming the second story of the engine and boiler house, a brick construction, 53½ ft. long and 29 ft. wide. In this room the clay is ground by one of BACON'S grinding mills, and delivered in a powdered state into a small clay pocket, alongside of the coal dust pocket previously described. In the same room is an iron tank, 6 ft. high and 6 ft. in diameter, in which is prepared a composition of lime, rye flour, and water, which, in a liquid state, is discharged into a wooden reservoir or tank placed under the coal dust and clay pockets. In front of these pockets is placed a very ingenious machine, by means of which 95 per cent. of coal and 5 per cent. of clay are continually and mechanically taken out of their respective pockets and delivered under a chain elevator and there sprinkled through a perforated pipe with the liquid from the wooden reservoir. All the materials which are to make the lump of fuel are here brought mechanically together, and are taken up by the chain elevator, which carries them up and discharges the whole into a mixing machine. This machine has a capacity of six tons, and it delivers through two openings at the bottom, regulated by hand wheels, the materials on a leather belt 3 ft. wide, which carries and discharges them into the hopper of the press, between two rollers, on the face of which are milled out semi-oval cavities, connected by small channels. These are the moulding rollers, and the materials passing between them are compressed and moulded in the shape of eggs, and delivered in that shape on an endless wire-cloth belt, which enters the drying oven on top. In this oven, which is a brick construction, 80 ft. long, 14 ft. wide, and 26 ft. high, there are five endless wire-cloth belts, geared together, and travelling in opposite directions. This oven is heated by a fire placed at each end to from 250° to 300° Fahr. The coal enters, as said before, on the upper belt, coming from under the press, travels five times in succession the entire length of the oven, at the speed of twelve feet in one minute, falling from one belt to another, and finally comes out perfectly dry on the lower wire cloth belt, which enters the waterproofing building.

In this building the lumps of coal are discharged into a tank containing a certain liquid composed of candle gum dissolved in crude benzine. In the same tank, and guided on both sides by a curved groove, travels a wire cloth belt on which the lumps are discharged from the lower belt coming from the oven. The lumps are thus immersed mechanically into the waterproofing liquid, while the belt describes a curve into the tank, and the same lumps are then carried, waterproofed, into the evaporating

oven, where all the vapours of the benzine are collected and carried through large pipes into a condensing coil 200 ft. in length. The condensed benzine returns to the main tank, and the coal, perfectly dried and waterproofed, is carried up by a chain elevator, and discharged on another wire cloth belt, which runs the entire length of the coal pockets—100—and delivers the coal in any desired pocket.

From beginning to end, the coal is in motion; from the point where it is dumped as dust, until it reaches the coal pockets as fuel. It travels about 800 ft. in about one-and-a-half hours. Buildings and machinery are of the most substantial character. The production, with the machinery erected, will vary from 125 to 160 tons per day. —*American Journal of Engineering*. See PEAT.

FUR. Vol. ii. p. 514 gives a list of the various kinds of foreign furs imported.

Fur cutting.—The name given to the process of removing the fur from the skins of rabbits and other animals, for the manufacture of felt. The industry is carried on at London, Manchester, Brandon, and Norwich. The following description is taken from notes made in the workshops of Mr. ROUGHT, of Brandon, Suffolk, in the neighbourhood of which place there are very extensive warrens.

The rabbit skins are taken direct from the collectors and sorted into four kinds, namely, *beats*, or full-grown rabbits 'in season,' that is, in November and December, when they are from six to nine months old; *racks*, or young rabbits about two months old, which have not kept their first coat; *quarters*, which are intermediate between the two former, the full coat just appearing; and *suckers*, or very young rabbits, about a month old, of very little value. The skin of a sucker is white, of a quarter, black and white striped, of a rack all black, and of a beat all white. Tame rabbit skins are simply divided into bests and seconds according to their quality. Hare skins are sorted according to the season, the term *sages* being used for those which are between young and full grown, in the same manner as the term *quarter* is applied to rabbit skins.

The skins are generally sent to the fur-cutter in bags and are taken to the *pulling room*, where they are opened, the fat scraped off, the fur of the ears, the nose removed, and the skins spread out. Girls perform the operation of pulling, the skins being given out in bundles of five dozen, called *turns*, and a girl will pull from one to one-and-a-half turns in a day. The pullers sit against a long bin called a *pound*, having a ledge running along each side, against which the skin is pressed with the knees, so that the breech is next to the ledge. The forefinger and thumb of the right hand are protected by a stall, here called a *hutkin*. The skin is first *carded* with a *rake*, which is the blade of an old shear or piece of a scythe, with large teeth notched into its edge. This removes the blood, clots, dirt, &c., known as *claggings*. To prevent the fat from damaging the skin, it is chalked or *whitinged* before being carded. The next process is *pulling*, which is done with a pulling knife made of steel. It has a stout 'square' blade about four inches by one inch, and a short round handle. The blade rapidly wears into a concave shape, and after about three weeks' use is in the best working order. The skin having been carded, the fur is grasped by the thumb and pressed against the knife, which is held by the fingers, the little finger alone clasping the blade. A steady pull removes the hair, which falls into the pound, leaving the skin with the fur upon it. This action is performed over the whole skin. The pulled skins are then made up into turns and taken to the office, where they are counted and booked. The claggings are removed from the hair by beating upon a common riddle, the former being used for manure, and the latter for stuffing beds.

The next process is *carrotting* or dressing the skin, to preserve it from decay and the ravages of insects. This is performed in a cool room, upon a slightly inclined slate table grooved along the edge. Upon this are placed slabs of slate also inclined, and resting upon blocks of wood. The skin is laid fur upwards upon a slab, and held at the head with a small pointed stick. The carrotter then dips a cocoa-fibre brush having a curved handle into a composition of secret character, and rubs the skin therewith. The composition used by Mr. ROUGHT is one of his improvements in the trade. The skins are then laid 'wool to wool' in pairs, and stacked in a rack until they are removed to the *stove-house*.

The *stove-house* is full of iron racks upon which are placed iron rods, which receive the skins. The temperature is regulated according to the state of the atmosphere, and varies from 110° to 170° Fahr. In from 8 to 12 hours the skins are dry.

They are then removed to the *machine room*, where they are brushed and cut. Brushing was formerly done by boys, but machinery is now introduced. The brushing machine used by Mr. ROUGHT is the invention of his nephew, Mr. E. H. BEATON. Feed rollers take the skin beneath a revolving brush, which cleans out the loose hair and sand, and shoots it forward into a receptacle under the machine, the skin passing out behind. One machine will brush before breakfast more skins than a boy could

do in a day. The machine is geared on to the main shafting of the machinery, and is said to be the most effective appliance in the trade. A bonnet protects the workman from any flying particles. After being brushed the skins are again made up into turns and taken to the office, from which they are given out daily to the cutters.

The fur-cutting machine is very effective and ingenious. Four spiral cylinder knives work against a straight-bed knife so as just to touch it. The skin passes between two ribbed feeding-rollers to the knives which cut the skin into fine shreds, the fur passing forward underneath the bottom feeding-roller on to a tin plate, while the shreds of skin fall into a receptacle beneath the machine. So accurately is this process performed that the fur passes on to the tin plate in its natural position, so that it is scarcely possible to perceive that the skin has been removed. The bed-knife has a long and short basil side, the shorter one supporting the skin. The knives are ground daily, and the revolving knives are brought up to the bed-knife as often as they wear down. With rough skins the knives wear down in ten minutes, with ordinary skins in from two to three hours. The wind of the revolving knives causes the waste to fly backwards into a flue-box.

The skin shreds, or *pelt*, are used in the cloth trade for sizeing, and are also manufactured into glue.

Boys remove the fur upon the tins to the *lockers*, or girls, who sort the different kinds of fur. They stand at a table and place each kind of fur in a separate compartment of a long box. Ordinary wild-rabbit skins are divided into seven kinds of fur, namely:—

(1) P. B. C. *i.e. Picked Cony Back*, the dark-brown fur from the centre of the back; (2) L. C. *i.e. Light Cony*, the light brown fur which surrounds the P. B. C. and extends from neck to breech; (3) *Sides*, the white fur from the sides of the skin; (4) *Red Neck*, a red patch over the neck; (5) *Pate*, a black patch on the head; (6) *Cheeks or Grey*, the fur from the cheeks, and (7) *Tail*, black and white fur of the tail. These qualities are packed in 5 lb. air-dried brown paper bags marked, and packed in crates or cases containing from 80 to 100 bags each. Three lockers and an assistant are allowed to each machine.

Hare skins are rather differently treated because the hair or fur is different from that of rabbits. In these latter, the smooth long hair which will not felt is separate from the jagged fur, but the hair on hares is smooth above and jagged below. The smooth part is cut away with shears, and the fur then cut as above described. At present hare wool is not sorted, but formerly it was divided into *black back*, *brown back*, *sides*, *pate* (useless), *cheeks* and *tail*, as in the case of rabbit wool.

Beaver and musk rat skins are first washed and stretched on boards, after which they are pulled, carrotted, and cut as above described. The beaver fur, known as wool in the trade, is divided into *silvery*, *pale*, *white*, and *brown*; the musk rat into *brown* and *white*.

The quantity of skins used is enormous; a single machine cuts 100 dozen skins per day. The chief stock comes in between January and March, and 200,000 dozen skins is no usual stock to see in Mr. Robert's factory.

A process known as *yellow carrotting* is occasionally employed. The skins after being carrotted are heated by super-heated steam, and the fur changes to a golden yellow colour.—S. R. J. S.

The Fur Trade of Leipsic.—The price of furs is to many persons in Europe almost, if not quite, as important as the price of coals, and a general 'strike' of furred animals would produce an amount of misery and inconvenience only to be equalled by a general strike of colliers. Some interesting information with regard to furriery is given by Consul-General Tauchnitz, in his Report on the Leipsic Easter Fair, 1873, and on the fur trade, lately printed. To this last fair, as to former ones, were brought in abundance the produce of Siberia, Russia, Norway, and Sweden, of all Central Europe, of the United States of America, Canada, the Hudson's Bay Territory, North-West America, Alaska, the Aleutian Isles, and from China. The goods are exported to America, Russia, China, Turkey, to Hungary and the Austrian States, to England, France, and Italy; a considerable quantity also remaining for use in Germany. Mentioning first the productions of Central Europe, there were imported for the last fair in round numbers 120,000 foxes, 200,000 pole-cats, 50,000 rock martens, 20,000 pine martens, 20,000 badger skins, 6,500 otter skins, and 125,000 black cats. Foxes fetched from 16 to 22 thalers, according to quality; on an average about 18 thalers per 10 skins. For pole-cats but moderate prices were paid, a large stock being offered; they sold for from 60 to 110 thalers per lot of 40 skins, according to the country. Rock martens reached six thalers per skin for German, 7½ thalers for Bosnian and Greek goods; pine martens 6 to 7½ thalers per skin. Black cats were sold from 9 to 15 thalers per dozen. Of Russian and Siberian furs were offered 2,000,000 squirrels of all sorts, 160,000 ermine, 30,000 kolinsky, and 8,000

Siberian sables; these were sold from 15 to 35 per cent. cheaper than in last year. Of the productions of North America, about 1,500 sea otters were quickly bought up by several Russian merchants. About 30,000 beavers (40,000 were reserved for the demand in England) found in general a good sale at former prices. Of 10,000 other skins, on account of the high price, only about the half went off the market. 5,000 Virginian pole-cats were entirely cleared out at high prices. Of 6,000 bear skins, about a third remained unsold, owing to the mildness of last winter, and the sale of racoons suffered from the same cause, only half of 220,000 skins being disposed of. 950,000 skunks, considerably cheaper than last year, found a tolerable sale. 800 silver foxes and 2,500 cross foxes met with but a moderate demand; 46,000 red foxes, about 5 per cent. cheaper than last year, were caught up by Greek, Russian, and Galician merchants, and all but about 20 per cent. of the store was sold; 5,000 grey foxes and 9,000 kit foxes were about 10 per cent. cheaper; 3,500,000 musk were much sought and well sold, owing to the prospect of a diminished supply in America; 16,000 sables found a quick sale, especially in the better sorts; of 60,000 small otter skins, only about two thirds were sold, owing to the large supply. Of the most important European goods are especially mentioned dyed sealskins; this fur is in general favour in England and America, and also in Germany and France, and the whole was sold out, many orders remaining unexecuted. Prepared squirrel backs and squirrel bellies found the usual demand. Coloured Persian and Astrachan furs found a good sale at moderate prices. French and Belgian rabbit skins were brought in great quantity, and found a sale at a lowering of about 10 per cent. in price. Dutch swans and geese found a good sale, also polished rabbit skin goods and marmot lining, the latter 15 per cent. cheaper than last year. As the day seems to be approaching when families will depend more on fur than fire for warmth during such weather as we are now experiencing, these details of the Leipzic fur trade have especial interest at the present moment, and are calculated to raise vermin in general estimation.—*Pall Mall Gazette.*

FURNACE. (Vol. ii. p. 517.) M. Gruner has given the results of some elaborate experiments on the amount of heat utilised in different furnaces, arriving at the following conclusions:—(1) In furnaces urged by a blast, only 1·7 per cent. of the total amount of heat expended on, or at most 3 per cent. of the heat generated, is turned to account in the fusion of steel in crucibles. (2) In reverberatory furnaces, in which the steel is melted in pots, the amount turned to account is 2 per cent. of the total heat, or 3·5 per cent. of the heat generated. (3) In the Siemens furnaces for crucibles, 2 or 2½ per cent. of the total heat is utilised. (4) In glass works, where large masses are dealt with, 3 per cent. in the ordinary furnaces, and from 5½ to 6 per cent. in the Siemens furnaces is turned to account. (5) In melting directly on the sole of a reverberatory furnace, the amount utilised is 7 per cent. for glass, and 5 per cent. for pig iron. This proportion rises to 15-18 and even 20 per cent. in well-built Siemens and Ponsard furnaces. (6) The amount utilised is much greater still in furnaces where the fuel is mixed with the substance to be melted. In old-fashioned cupolas 29 or 30 per cent. of the heat generated was turned to account; in modern cupolas, which are higher, of quick working, and with a diminished zone of fusion, more than 50 per cent. of the heat given out is generally utilised. (7) Lastly, the large blast furnaces utilise, according to their working, from 70 to 80 per cent. of the heat generated, or 34 to 36 per cent. of the total heat which the fuel consumed would be in a condition to furnish by complete combustion. In the Hoffmann circular furnaces the same amount, 70 to 80 per cent., is utilised.—*Société d'Encouragement.*

Gas Furnace, Bicheroux.—The following are the principal features of the Bicheroux furnaces:—The heating furnace is of the ordinary kind, but where the grate is usually placed, passages are built for the gas and air. The furnace is connected by means of a canal with the producer, the latter being of a very simple construction; it consists of two vertical side walls, and inclined front and back walls. The front slope is supported by a strong framing, the back slope by brickwork. The whole is vaulted over with fire-bricks. At the bottom of this so-formed chamber are the fire bars about 2 ft. 6 in. long; they can easily be taken out to enable the stoker to draw the clinkers from the producer. There are besides two folding doors for the ash-pit, by means of which the air can be completely shut off, so as to stop the generation of gas. At the top in front are three or four stoke-holes through which the producer is fed. These stoke-holes are either closed by bricks or simply by small coal. Before the stoke-holes is a platform for the stoker, and a supply of coal. The producer may be placed entirely above ground, and then requires the side framing; or it may be placed underground, when the side framing may be replaced by brick walls. If the ground permit it, the producer should be placed underground, as it then does not stand in the way of the workmen. The distance of the producer from the furnace

depends on the circumstances in each case; but in order that the gases may not be cooled on their way from the producer to the furnaces, it is perhaps advisable to place them not too far apart. However, in cases where the producers have been placed about 70 ft. from the furnaces, the results have been as satisfactory as when they were close together.

The gas flue is built of fire-bricks, and may advantageously be placed underground, when the framing may be dispensed with. This flue is sometimes provided with a slide valve of brick or iron, to shut off the gas when required; sometimes the valve is placed in the furnace, a little under the holes for the air; sometimes there is no valve. The consumption of coal in the generator may be stopped by closing the doors of the ashpit, and making them air-tight by means of clay.

The furnace itself is, as already stated, the ordinary one, only in place of the fire-grate passages are built for the admission of gas and air. The gas passage is the continuation of the flue coming from the producer, the gas entering the furnace over the bridge. Before it passes the bridge, however, it is met by a number of air currents at one or both sides. The air passes from the flue at the sides of the gas passage into the latter through a number of small holes, formed by fire-bricks, placed a little apart from each other. The air thus admitted is previously heated, which may be done in various ways, either in the producer and gas flue, or at the bottom, or sides, or crown of the heating furnace. The air enters at the end opposite to the entrance of the gas, and travels slowly under the hearth-bottom (thereby keeping it cool, and protecting it from rapid destruction) to a box of cast iron. From thence it enters the air passages at the sides of the gas passage. By means of a slide in the box, the furnace-man can control the admission of air, and thereby the heat in the furnace, to a nicety. The ignited gas expands over the bridge into the furnace, where it heats the iron. Thence it goes under the boiler into the chimney.

The BICHEROUX gas furnaces share with other gas furnaces (SIEMENS, PONSARD, &c.) several advantages over the old furnaces worked with solid fuel.

Amongst others the saving in fuel is considerable; at Round Oak, for instance, when working single shifts only, it amounts, we are informed, to 40 per cent. Another great advantage is that inferior coal may be used in the producer, which could not be used in the ordinary firing furnaces, while, the combustion being perfect, no smoke issues from the chimney, and the control of the admission of air being so complete, the waste of iron is considerably reduced. The inventors, Messrs. BICHEROUX, state that at their plate-works in Duisburg the waste for double-heated heavy boiler plates amounts to 13 per cent., and in double-heated light ones to 16 per cent. For the same reason the fire-bricks of the furnace are better preserved, not being cut by the presence of superfluous air. The furnace-man also is enabled to concentrate all his energy on his proper work, the heating of iron, as the stoking is done by ordinary labourers. He can, therefore, heat more iron; at Ougrée, for instance, in furnaces where one class of iron tyres only is heated, it has been found that the old firing furnaces heated 15 tons per 12 hours, the BICHEROUX gas furnaces of the same size 16 tons in the same time.

In comparison with some other arrangements of gas furnaces, the BICHEROUX system has the advantage of being simple and easily applied to existing furnaces; while the working of the BICHEROUX furnaces does not differ from that of the old firing furnaces, the ordinary furnace-man is therefore able to handle the BICHEROUX furnace in his usual way. The waste heat of the furnace in the SIEMENS and PONSARD systems is used for heating the regenerators. In BICHEROUX's system it is used for heating the boilers, which are usually attached to the heating furnaces. The waste heat from the furnace being so regular, the boilers and brickwork are better preserved; not being subjected to variations in the temperature, and the combustion being complete, the flues require no cleaning or very rarely.

The same system has also been advantageously applied to boilers, to reverberatory furnaces for smelting purposes, to furnaces for heating BESSEMER ingots, &c. It has also been applied to puddling furnaces, but it does not seem with the same success, at all events not at all places. Whilst some manufacturers claim a complete success, others state that the results obtained are not better than at ordinary puddling furnaces. It is, therefore, not advisable to apply BICHEROUX's system to this class of furnace until greater experience has been gained with it.

Mr. CASSON, whose name is associated with the CASSON-DORMOY furnace, which has been for some time most satisfactorily employed as a re-heating furnace, who had trials made with two of these furnaces extending over several weeks at the Round Oak Ironworks, has given the following as the results obtained in connection with a 16 in. mill:—

	Week ending November 11			Week ending November 20		
	Tons	cwt.	lb.	Tons	cwt.	lb.
Charge	110	4	22	108	6	10
Finished iron	93	2	0	92	5	84
Ends cut off	9	17	36	9	0	110
Waste in the furnaces	7	4	98	6	19	40
	Or 6·57 per cent.			6·43 per cent.		

averaging 6½ per cent. of the charge, and all this, though the mill worked only single turns, 6 day turns a week, and the rolls were changed 24 times in the first, and 25 times in the second week.

In the week ending December 18, 1876, the mill worked on double turns, 10 times in all, with the following results:—

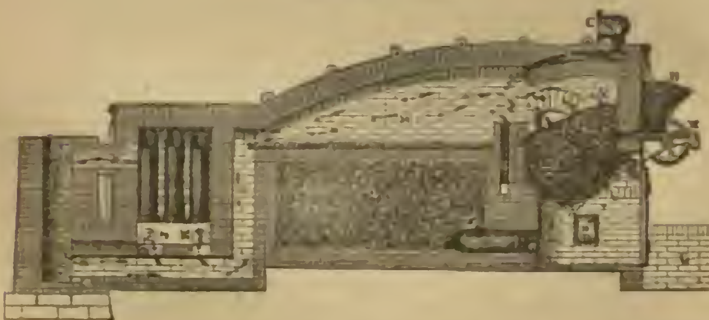
	Tons	cwt.	lb.
Iron made	185	13	14
Coal consumed	66	13	0

one ton of iron requiring therefore 7·18 cwt. of coal (Staffordshire coal).

Gas furnaces are also applied with great success to boilers, furnaces for heating Bessemer ingots (at Angleur, near Liege, 1½ cwt. of coal were consumed per ton of steel), to puddling furnaces (at Ars-sur-Moselle 1 ton of iron was made with 6¾ cwt. of coal), and to other furnaces.

Furnace, Gas Re-heating.—Mr. W. A. Sweet, of Syracuse, N.Y., has devised a gas re-heating furnace which possesses many recommendations. The section (*fig.* 2348) represents the furnace as now built for heating steel and iron for rolling-mill purposes. The heating-chamber is not different from that of other furnaces used for the same purpose. The gas-producing chamber is peculiar, and the manner of introducing the coal is perhaps the most novel and useful feature of the furnace.

2348



The coal used is fine bituminous, or semi-bituminous, but a mixture of two-thirds semi-bituminous with one-third anthracite may be used, or anthracite may be used with a very bituminous coal, half and half. The coal is thrown into the hopper, B, where it rests on the slide or plunger, which is worked in and out by the crane, M. The coal is used very wet, that is, with all the water it can be made to absorb. The slide or plunger is worked back and forth with a crank and gearing, which works into the two racks, at each end of the plunger. This gearing is so compounded that eight turns of the crank puts the plunger in, and of course the same number brings it back again.

The plunger should always be left at the point shown, that is, just through the plate of the furnace, with a charge of coal in front of it. This front plate is thickened with a lip to break any lumps that may be in the coal, and the power obtained by the crank is sufficient for this purpose. Four turns in are given, then eight out, then four in, and the plunger left as shown.

The wet coal keeps these plates comparatively cool, and, when first introduced, retards the low gases sufficiently, to have them thoroughly heated by passing through the red-hot mass of the burning coal above. They are thereby properly heated and mixed with the gases of a higher temperature coming from the coal that has been longer in the furnace, and those which arise from the combustion of the coke and which

pass by the bridge-wall, and through the crown brick D, both of which are tubular, and made of fire-brick material.

When the furnace is run for high temperatures, no smoke is seen issuing from the chimneys, which are small flues projecting a little only from the roofs. When the furnace is run for steel heating, a full carbonising flame must be employed to heat the stock properly, and while we do not get as much economy in coal, we more than make it up in saving of steel. Recently 9 tons of 3 in. square Norway iron were rolled into small shapes at less than 1 per cent. actual waste. The furnace waste was nil, all the waste being train or rolling waste.

The hot-blast stove is very similar to the hot blast of ordinary blast-furnaces. The flame is led down through the flue, N, under the arch protecting the pipes, B, and a sufficient amount of the heat or flame is let into the oven, N', to heat the pipes, and passes out of the passage governed by the valve, N''. The blast can be heated up to 900° F., according to the pyrometer of BROWN, and there is no difficulty in governing it by using a number of the pipes according to the heat of the air wanted. From the stove the hot air is carried into the flue connecting with the tubular crown and bridge wall.

The object aimed at in the construction of this furnace was to be able to heat or melt as much steel as was done by others at a less cost of furnace 'plant,' and less labour in practical working, together with less time for heating, and less cost in repairing.

Nine lb. of billets are now heated with 1 lb. of coal. These billets are rail-ends, from 1 to 3 ft. in length, and 67 lb. to the yard. The furnace and rolling waste is 2 per cent.

The cost of the furnace is $1,100, and of the stove $400.

Description of Furnace, fig. 2348.

B. Hopper for coal.
A. Coal and coke in furnace.
F. Standing open grate.
L. Grate-frame to drop free when letting the fire completely out.
H. Dump-plate for cleaning out ashes and cinders once in five hours.
O. Air-pipe into ash-pit—cold air.
K. Tubular brick for inner bridge-wall for hot air.
X. Lining to protect the tubular brick, K, and to be repaired.
D. Tubular crown-brick for hot air.
W. Heating-chamber.
N. Flue for heat and flame to the chimney-arched passage under the iron pipe, B, with holes through it N' to let the proper quantity of heat into the chamber surrounding the pipes.
B. Pipes to heat the blast to the proper heat, governed by the valve, N'', into the chimney, S.

Furnaces, Heat in.—Mr. EDWARD ALFRED COWPER, in his provisional specification for 'Improvements in the means of applying Heat in Reverberatory Bed and Rotative Furnaces, and apparatus for that purpose,' thus describes his invention :—

'This invention relates to the means of applying heat in furnaces such as those employed for puddling, melting, re-heating, and other operations conducted on a stationary or rotating bed or in a rotating cylindrical vessel, and to apparatus for that purpose. Several methods of applying heat in such furnaces have been adopted, as for example, by the flame resulting from the combustion of solid fuel on fire-bars contiguous to the furnace-chamber, or by the flame resulting from the combustion of gaseous fuel and air, and in some cases increase of heat and economy of fuel have been obtained by the use of regenerators to heat the air and gas before their mixture, such regenerators being themselves heated by the products of combustion escaping from the furnace-chamber.

'According to my invention I apply in the furnace-chamber a blow-pipe jet or several such jets directed on the material under treatment, the said jets consisting of combustible gas and of air, which air I previously heat by passing it on its way to the furnace through a stove of the kind described in previous specifications of patents.

'This stove may be heated by the combustion of solid or gaseous fuel, or by the waste heat of smelting or other furnaces, and when it has been so heated its communication with the source of heat is cut off and the blast of air is directed through it, so as to be heated before entering the furnace-chamber. For convenience of working the stoves are provided in duplicate, so that the one can be receiving heat while the other is heating the blast; and a pair of such stoves thus worked alternately may serve for a number of furnaces arranged near them. The gas may in like manner be

heated by its passage through separate stoves, but as this would involve complexity of arrangement, I prefer to use the gas cold or to heat it partially by passing it through a coil of pipes in the base of the chimney, by which the products of combustion are conducted from the furnace. Both the air and the gas may be supplied under pressure; I prefer, however, for the sake of simplicity, to apply pressure only to the air-blast, and to so arrange the air- and gas-nozzles that the current from the former shall, by its inductive action, create a current in the latter.'

Furnace, CRAMPTON's *Coal Dust*.—The principle of the CRAMPTON furnace consists in the introduction of streams of air and powdered coal, in properly adjusted proportions, and mingled together into a combustion chamber, in which they are burnt, the products of combustion passing into a chamber beyond, where the heat is utilised. Attempts have been made to work out this principle in practice, but they have failed from various causes. In some cases the material composing the combustion chamber has been rapidly destroyed by the intense heat of the streams of fuel and air impinging upon it. In others the fuel has not been reduced to a sufficient degree of fineness, nor properly mixed previous to its transit through the furnace, while in others, again, no efficient means have been provided for regulating the combination of air and fuel. Above all, the necessity of counteracting the tendency of the particles of fuel to separate from the air in no case appears to have been recognised. But unless provision is made to prevent the separation of fuel and air no good can be expected to result, inasmuch as the separated particles will either be deposited unconsumed, or only partially consumed, in the combustion chamber, or in the working chamber, or will be driven forward into the flue of the furnace. With all these difficulties Mr. CRAMPTON has had to deal in developing his system, and one by one he has succeeded in overcoming them.

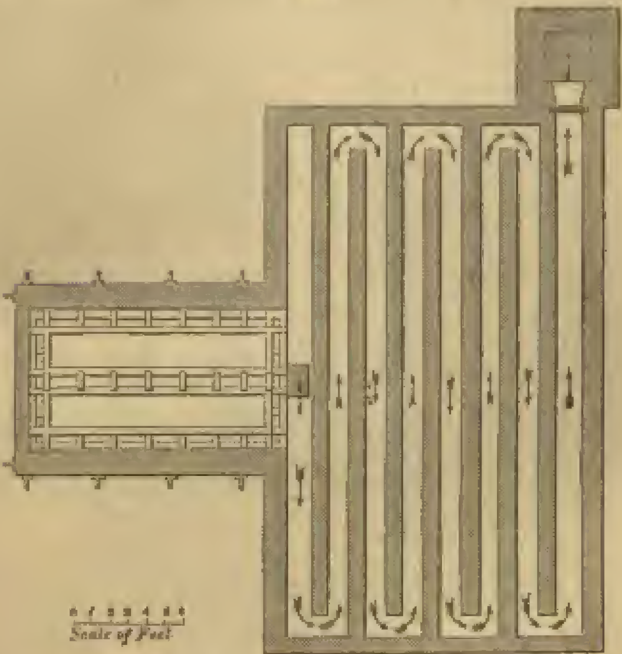
Two results only have been referred to as accruing from this invention—the utilisation of coal-dust and the perfect combustion of fuel. There is, however, a third, and equally important, question, which has received solution by the same means—that of applying the heat obtained by this system to mechanical puddling. This was the last fact accomplished, and it has imparted additional interest to the invention. This final improvement grew out of the last difficulty with which Mr. CRAMPTON had to contend—namely, the preservation of the brick interior of the combustion chamber. The system was at first applied to an ordinary reverberatory puddling furnace, the fireplace of which was converted into a combustion chamber by covering the fire-bars with a layer of refractory material. This soon became coated with a film of flux which preserved it from the destructive action of the impinging streams of fuel and air; but the roof of the chamber over the bridge, upon which the intense heat was deflected, was acted upon and rapidly destroyed. It then occurred to Mr. CRAMPTON that if he presented the whole surface of the chamber to the action of the flux, every part would be equally preserved. To do this it was only necessary to make the furnace revolve upon a horizontal axis. There yet remain to be noticed two other practical results which have been achieved by Mr. CRAMPTON in the furnace under notice. On the one hand, he has perfected a mechanical system of supplying the fuel to the furnace by self-acting apparatus, and on the other he has prevented the production of smoke. This latter result follows, as a matter of course, inasmuch as the only conditions under which the furnace can be successfully worked are exactly those which render the production of smoke impossible. The furnace constructed at Woolwich demonstrates the use of powdered fuel in a free condition, perfect combustion, mechanical puddling, self-acting feeding, and smoke consumption, to be accomplished facts.

The furnace by which these results are obtained stands in the Forge Department of the Royal Gun Factories. Near it, and placed in a corner of the building, is the machinery for reducing ordinary coal-dust to a state of fine powder, which is done by grinding it between a pair of common mill-stones, and afterwards passing it through sieves of the required degree of fineness. It is found that the greatest amount of useful effect is obtained from fuel which has passed through sieves having 900 meshes to the square inch. From the sieves the fuel is conducted by an Archimedean screw to the feeding apparatus, which consists of a square chamber or hopper having two revolving stirrers so arranged at the bottom that the whole area of fuel is kept in a state of gentle agitation. These stirrers force the fuel through a horizontal opening in the front of the hopper on to a pair of rollers of different diameters, placed with their axes one above the other in a nearly vertical line. By this means a continuous and unvarying supply of fuel is delivered into an annular tube, leading into the furnace, and at a point where it is taken up by a strong current of atmospheric air. Both the supply of fuel and the supply of air can be regulated with the utmost precision according to requirement by means of a very simple arrangement which cannot easily be put out of order. The current of air is produced by a fan placed near to the furnace. The annular tube is fixed to the revolving furnace, while within it

pass the pipes through which the water is circulated for keeping the furnace itself cool on the outside. These pipes lead, the one from a water tank to the casing of the furnace, and the other from the casing to a waste pit. The water at the point of exit has a temperature of about 80° Fahr. The furnace itself is externally an iron cylinder, about 12 ft. long and 7 ft. in diameter, revolving about a horizontal axis, upon four bearing wheels let into a bed-plate on the ground. Around the furnace, at one end, is a toothed wheel, which gears into a pinion connected with a small engine—a steam winch, in fact, with a pair of 5-in. cylinders and 10-in. stroke—by which it is made to revolve.

Furnace, Double Muffle.—This furnace was designed for the reduction of the hydrous silicates containing copper. The following description is derived from a paper read before the American Institute of Mining Engineers, at Washington, by Professor B. Silliman, and printed in the *Engineering and Mining Journal* of New York.

2349



The experiments made by Dr. Hunt having demonstrated the fact that the copper contained in the 'clay ore' of Jones's Mine was rendered completely soluble in the bath of ferrous chloride used in the Hunt and Douglas process, after heating in contact with carbonaceous matter in a close vessel, Professor Silliman set himself to devise a form of muffle furnace adapted to the treatment of large quantities of these and similar ores by a continuous process. The result is shown in the accompanying diagrams, reduced from the working drawings, after which this furnace was built early in 1876, at Phoenixville, by the Chemical Copper Company on their works at this place.

The peculiar character of this ore determined the form, dimensions, and position, with reference to charging and discharging of these muffles. The ore arrived from the mine with from 20 to 25 per cent. of moisture, and when dried at 212° Fahr., or more slowly at lower temperature, it falls to a light incoherent powder, with occasional lumps of undecomposed rock. In this condition it is readily mingled with coal dirt or any like reducing agent, and requires no other preparation for the muffle than the use of the shovel, to mix it well with the reducing agent. As it is a remarkably good non-conductor of heat, it was obvious that the mass, to be heated through in a reasonable time, must not be too thick, while its weight must be sustained in a way to avoid undue strain upon the walls of the muffle. These walls must be as

thin as practicable, to favour the more rapid transmission of heat, and must therefore be so constructed as to admit of being stayed on the sides at frequent intervals to resist the lateral thrust of the very mobile mass of pulverulent ore, which, for obvious reasons, must be charged at the top and drawn from the bottom of each chamber. These considerations led to the form adopted, viz., two vertical muffles, standing upon very strong bridge tiles, seen in horizontal section, on the line u v, *fig.* 2354, and in plan in *fig.* 2351, on the same plane. The vertical section of the muffle is seen in *fig.* 2352, drawn in the plane u u of the longitudinal section, *fig.* 2354, which is the key to all sections.

The walls of the muffles are built of the best fire-brick, very carefully laid, one course thick (about 4½ in.), and bonded to the surrounding walls at frequent intervals, as seen in *figs.* 2352 and 2354. The dimensions of the muffle chambers are each in height 10 ft., in depth 12 ft., and in width 2 ft., calculated to hold from 14,000 to 15,000 lb. each of dry ore. This ore, as mined, measures about 33 cubic feet to the miner's ton of 2,352 lb., and by drying suffers very little change of volume, the cubic

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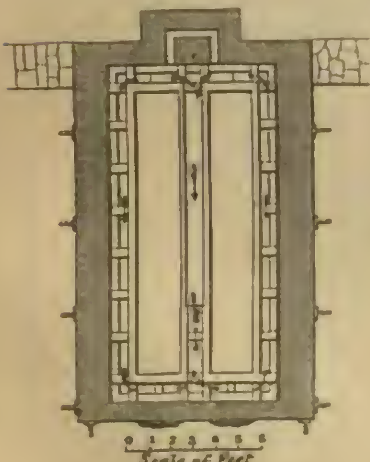

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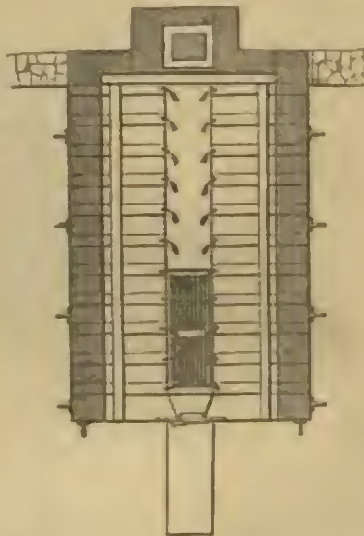

foot of dry ore weighing about 75 lb. It was expected that this volume of ore could be treated in from 24 to 36 hours, the chief ground for this expectation being the action of the gas retorts, which afforded the nearest known term of comparison. We shall see beyond how far this expectation was realised in actual experience. The fire-place, seen in *figs.* 2351, 2352, and 2354, was placed centrally beneath the two muffles, and the course of the heat is clearly indicated by the arrows seen in the several sections, being in the main outward from the fire, and then upward, by way of the outer walls, and downward again between the muffles, where the current is directed by a horizontal diaphragm seen in longitudinal section (*fig.* 2354), compelling the escaping gases to seek the ascending flue to the drying-floors and chimney, only after enveloping the whole area of the muffle walls. In this, as in all points of detail, the long experience of Mr. William Edmondson in building gas-furnaces was most valuable. The effect of this mode of distribution of the heat is all that could be desired, giving a remarkably uniform temperature to all parts of the muffles. The drying-floor exposes an area of over 500 square feet of surface, beneath which the heat passes on its way to the chimney, as seen in *fig.* 2349, the flues being covered by large flat tiles sustained on the dividing walls, as seen in *fig.* 2354. Each muffle is provided with two charging-holes, as seen in the same figure, covered by an iron plate, perforated with a gas tube for the escape of gases and vapour given off in the process, and serving also as convenient handles for opening the feed-holes. The doors of dis-

charge are seen on *fig.* 2350, counterpoised and rising in vertical guides, the waggons to receive the reduced ore being placed immediately under the discharge.

The chemical reaction by which in these muffles the copper silicate is reduced to metallic copper is sufficiently simple, and may occur either by the direct action of carbon on the cupric oxide $C + CuO = CO + Cu$, or by the joint action of hydrocarbon

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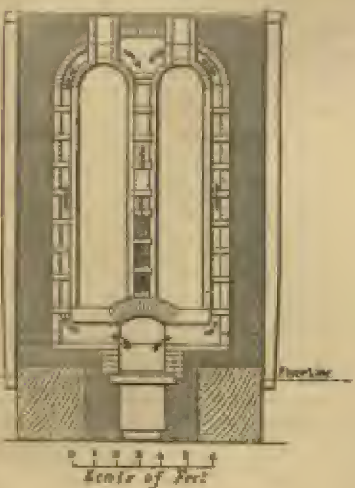

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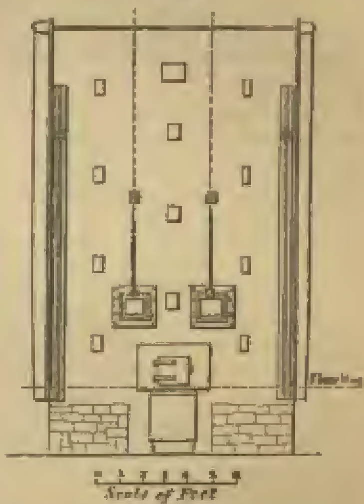

gases and carbonous oxide on the copper oxide producing water and carbon dioxide. Practically it was soon discovered that anthracite dust alone worked quite too slow, and required by far too high a temperature to be of any economic value; charges thus treated remaining, even after 80 hours' continuous treatment, only partially reduced. The dust of bituminous coal worked much more efficiently, the reduction being quite complete, but the time required being still greatly in excess of what was

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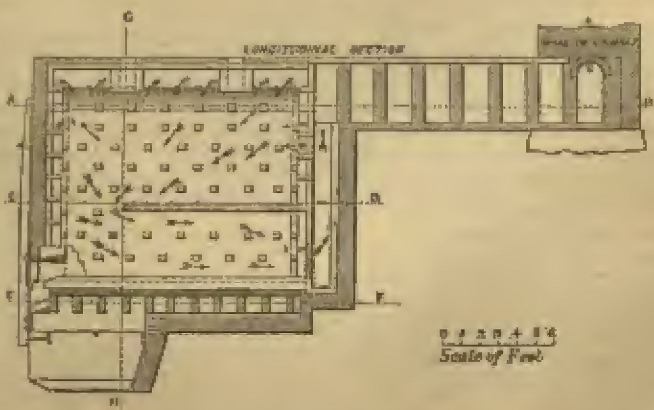


expected, or indeed requisite, as the result proves. But their mode of treatment was followed for many months, and with excellent results—the reduction being quite complete. With the use of about one-tenth of bituminous coal-dust to the charge of dry ore, the verticals being incorporated upon the drying-floor, and about 1,500 lb. of dust to the charge being used, the time consumed on the reduction was about 60 hours. This was too long, reducing the effective result of the muffles in the amount

of ore to be treated, and increasing unduly the consumption of fuel. Resort was then had to coal-tar, one barrel of which (about 400 lb.) taking the place of 1,500 lb. of bituminous coal-dust, and completely reducing the charge in about 24 hours, and at a lower temperature than is required with the use of coal-dust. It is easy to see why this should be so. Coal-tar is a liquid hydrocarbon, deprived, in the act of its production from bituminous coal, of all light products, volatile at temperatures much below redness, but capable, at a high temperature, of conversion into heavy hydrocarbon vapours. When coal-tar is commingled, therefore, with the dry ore, and the charge is thrown into the muffles, no chemical action takes place until the mass reaches the temperature of dull redness in the dark (under 500° C.), at which temperature it is known that reduction of iron ferric oxides occurs in a stream of hydrocarbon gases. But at this temperature the coal-tar begins to give off vapours abundantly, which, penetrating the already heated mass at the opportune moment, do the work of reduction with rapidity and very thoroughly. Now, with anthracite dust, charcoal dust, or dust of coke, the reaction is at first only between the carbon and the oxygen of the ores, and this can happen only at a much higher temperature, and more slowly; the carbonous oxide found next reacting with the cupric oxide to form CO^2. With bituminous coal-dust a considerable part of the hydrocarbon gases are given off at a temperature below the reducing point of the copper salt, and are thus practically lost, while the coke remaining acts slowly, for reasons already stated, as well as being mechanically in a disadvantageous condition. Hence, the time consumed in effecting the decomposition is by far too great, even with bituminous coal. But the coal-tar leaves nothing to be desired, and when it is employed the proportion and dimensions of the muffles appear to have been calculated almost exactly for the desired result. Only in the mode of heating them is there room for an important improvement. The use of a gas-producer has been decided on to fill one or both the spaces seen upon the sides of the muffle in *fig.* 2349, and by this mode of heating a more efficient and economical result may reasonably be expected. It is proper to add that nine months' continuous use of these muffles has demonstrated their efficiency and economy, as no repairs have been required in the apparatus, and the renewal of the fire-box will be rendered unnecessary by the introduction of a gas furnace. The beautiful display of burning zinc, with its faint amount of glow of lambent green flames amid the orange glow of the incandescent ore, as the charges were drawn into the waggons by night, was described at the Washington meeting as one of the most beautiful of metallurgical phenomena. This happens only when the temperature is higher than has been found needful in steady working, and near that at which the ore slags. Consequently, it is no longer seen as the process is now conducted. The reduced copper is oxidised at once by the air on drawing the charge, and in this condition is readily dissolved in the Hunt and Douglas bath. A remarkable change is seen in the texture of the calcined ore, which is thus rendered quite granular and free to the passage of the liquors of the bath, while before heating, and the consequent loss of water of hydration, it is quite impervious to water.

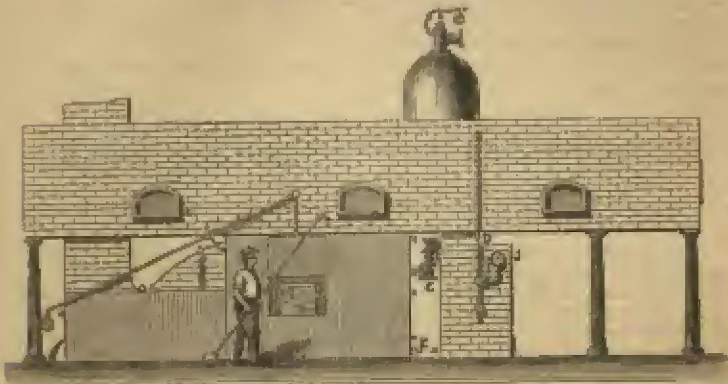
Furnace, Petroleum.—The furnace we are about to describe working with petroleum is the invention of Dr. C. J. Eames.

Fig. 2355 is an external view of the petroleum furnace, and *fig.* 2356 a section thereof. A B J D indicate the Eames vapour-generator, called simply the 'generator,' the main feature of the new apparatus and process. A is a cast-iron vessel, with horizontal shelves projecting alternately from opposite sides, over which shelves the oil, entering at D, at the average rate of 30 gallons or 200 lb. as a maximum per hour. This furnace, when heating 3,000 lb. of iron at a charge, and making steam for the rolls besides, requires no more—and it flows downwards in a thin layer, dripping from shelf to shelf. It thus meets a slow opposing current of steam heated and kept at a pressure of about 10 lb. per inch, and which passes upwards from the superheating coil R, enclosing the fire. Every trace of oil is taken up and swept on to a mixing-chamber, which occupies the former fire-space, where it meets the air-blast entering at the point K (the former ash-pit). It will be observed that the former 'bridge-wall' of the furnace is built up solid to the crown, except the space at H G, called the 'combustion chamber.' This consists simply of a cellular tier of fire-bricks placed on end extending all across over the old bridge-wall. Within these cells the combustion begins, and it is found that if this combustion space has a horizontal thickness of more than 18 in. the fire-bricks fuse down. I is intended to represent one of the piles of scrap iron, with its top and bottom 'covers,' of which, however, six, averaging 500 lb. each, are introduced at a charge in regular working. The course of the flame under, and back through, one of the flues of the boiler above and thence into the stack, is indicated by the arrows.

Professor Henry Wurtz, in describing the operations of this furnace, after dealing with the history of these vapour-furnaces, proceeds to the consideration of the chemical properties of petroleum:—

'Crude Pennsylvania petroleum is a mixture of a large number of compounds of carbon and hydrogen, of densities, boiling points, &c., varying among each other throughout a very wide range. According to one of the first authorities in the study of petroleum, Dr. VANDER WEYDE, three different compounds, when once separated from each other, boil at temperatures ranging from that of ice up to 700° Fahr., or higher. Its average density is about 45° Beaumé, corresponding to a gravity of 800, water being 1,000. Thus, one United States gallon of water weighing 8·332 lb. avoirdupois, one gallon of average crude petroleum weighs 6·67 lb. Its composition is about as follows:—Carbon, 84; hydrogen, 14; oxygen, 2; total, 100.

2365



The average latent heat of the vapour of petroleum has not been very satisfactorily determined, but it is known to be very low. Dr. Ure states it at 184, that of steam being 1,000; of alcohol vapour, 457, and of ether vapour, 313. That is, an amount of heat that will vaporise but 1 lb. of water and about 2·2 lb. alcohol, will vaporise 5·4 lb. of petroleum (assuming no important change of specific heat during the change of state). By measure the amount of heat or fuel that will vaporise 1 gallon of

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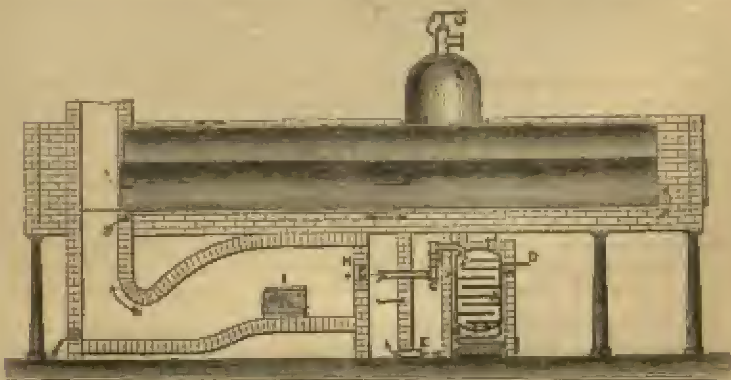


water should vaporise no less than 6¾ gallons of petroleum. This is an important practical point in this connection. The density of its vapour is very high, averaging, if the whole mass be converted into vapour, six-and-a-half times the density of air at the same temperature. At 500° Fahr. it will pass into vaporous form, except a trifling percentage, and as at that temperature air will weigh per cubic foot—

$$\frac{565 \times 492}{500^\circ - 60^\circ + 492} = 298{\cdot}26 \text{ grains,}$$

(565 grains being the weight of the cubic foot of air at 60°, and $\frac{1}{492}$ its co-efficient of

dilatation for the Fahrenheit degree), then—if we admit for it the same co-efficient of dilatation as for air—petroleum vapour at 500° weighs 1,939 grains per cubic foot, and 1 gallon of petroleum should yield only 24·08 cubic feet of vapour of that temperature.

The specific heat of liquid petroleum is stated to be ·4684, that of water being 1. The specific heat of its vapour does not seem to have been determined, but it probably will not greatly differ from that of the liquid. When boiled down a tarry residue is always left, which, on raising the heat, chars and leaves a coke-like mass behind.

The EAMES system consists of—

The Vapour Generator.—The plan and setting of this are such as to secure a successive evaporation of less and less volatile hydrocarbons from the oil; the *residua* (of high-boiling points, and those non-volatile without decomposition) ultimately reaching a horizon, on their downward flow, where the incandescent steam coming in below not only licks all that is vaporisable, but also any carbonaceous residue with formation of carbonic oxide and hydrogen gases.

The Steam Blast.—An important element in the calculation here is the fact that the time occupied in getting up a working heat on the cold hearth is reduced to so small a matter—but 35 or 40 minutes—that the necessity is by no means imperative of keeping the furnace in blast continuously, as with coal fuel; with which latter, in a furnace of this size, 12 hours is often required to get up a heat.

The Superheater.—The superheating of the steam blast is somewhat analogous to the heating of the air blast of a blast furnace. Such steam constitutes a vehicle of convection of the vapours, which cannot be sufficiently chilled afterwards, as ordinary steam would be, by the latent heat of vaporisations of the lighter hydrocarbons, to allow of the condensation of the heavier hydrocarbons into a spray, which latter could not be sufficiently diffused throughout the air blast to burn without smoke.

The Air Blast.—In connection with this factor of the process come in some of the most weighty considerations connected with the new system. It has already been shown that the total vapour from the whole of a gallon of petroleum, supposed to be at 500° Fahr.—at which point none of the hydrocarbons should be present in the form of liquid spray, but all as homogeneous vapour—should occupy but 24·08 cubic feet of space. In this space, deducting the hydrogen corresponding to the 2 per cent. of oxygen, there are 5·603 lb. carbon which require 14·941 lb. oxygen, and 0·92 hydrogen which requires 7·336 lb. oxygen, for complete combustion to carbonic acid and water; in all 22·277 lb. oxygen, equivalent to 1,268 cubic feet of air. Each cubic foot of the petroleum vapour, at 500°, requires, therefore, for complete and smokeless combustion, not less than 52·6 cubic feet of air at 60°, which latter must moreover be mingled with it perfectly and uniformly. Below this proportion it is certain that a flame may result in being more or less fuliginous. Hence we learn two things—the necessity of an enormous supply of air to this furnace, and that this air must be injected with rapidity, and caused to move in currents as sinuous as practicable to promote rapid and complete mixture with the combustible vapours. Thirty gallons of oil per hour may be stated as a practical consumption for one of these re-heating furnaces.

The flame of the EAMES furnace is likened to that of a blowpipe, the concentration and intense heat of which is explained by the great density of the oil vapour. The temperature of the fire-space or hearth of the oil furnace was determined by the method of POUILLET, and averaged 3,276° Fahr., the highest being 3,321·5° Fahr., or about 500° above the melting temperature of cast iron. The escaping gases were sufficient to supply steam every eighty minutes for running six large boiler plates through the heavy rolls, a result only previously accomplished with two coal furnaces. This was done by the consumption of 200 lb. of oil per hour, working charges of 3,000 lb. of scrap iron—consisting chiefly of old boiler plate, with boiler scale composed largely of sulphate of lime, phosphate, &c., still adherent. The mixture was well calculated to test the capabilities of the furnace for converting refuse scrap into boiler iron.

Starting with a cold furnace, a boiler full of cold water, and oil fed at the rate of 30 gallons per hour, 45 minutes was a maximum time to bring the whole fire-space to a dazzling white heat with 22·5 gallons of oil. Six piles of scrap, 3,000 lb. in all, being then introduced, 35 minutes more brought the piles to a high welding heat and raised the steam to 90 lb. pressure. The highest average time for charges of 3,000 lb. was 80 minutes; thus seven such charges, averaging 2,500 lb. of rolled iron each, could be worked in a day of 10 hours, with an average maximum consumption of 200 lb. of oil per hour, or 2,000 lb. per day, worth at Jersey City about $16½; so that the result is a production per day of about 8 tons of finished plate from one furnace, at a cost for fuel of about 9*s*. per ton. The iron made during the experiments was tested as to tensile strength, when the breaking load per square inch of original section averaged 20·6 tons. The remarkable uniformity of weld and homogeneity of the plates are well illustrated by prints taken directly from the laminæ developed on

the edges of some pieces of plate by etching. The results of some puddling experiments with this furnace, using cast scrap iron, have been apparently equally satisfactory. The most valuable points claimed for this invention consist in purity and density of flame being combined, securing, as in steam-raising, an efficiency of from 92 to 93 per cent. of the total heat engendered. The flame being smokeless, and like that of a BUNSEN burner, the boiler plates are kept clean, which results in the much larger steam-making absorption of heat; the rapidity with which heats can be raised renders continuous firing no longer indispensable to economical working; stoppage for repairs will no longer involve such expensive delays; the heat may be regulated with great precision, or be extinguished at any moment; and the practical calorific superiority of oil over coal, weight for weight, actually rises to a ratio of eight to one.

Calorifics of Petroleum.—The heating power of Pennsylvania petroleum has been determined with sufficient accuracy for all practical purposes. For oil from Oil Creek, H. SAINTE-CLAIRE DEVILLE, experimenting for the French Government in 1869, found a total calorific power of 9,963 Centigrade units, equal to an evaporation of 16·17 lb. of steam per 1 lb. of oil; and his actually obtained yield of steam was 14·05 lb. per 1 lb. of oil; 1,252 heat-units, out of the 9,963, by exact measurement, being lost in operating the chimney to produce draught, and 76 units by radiation, in all 1,328, or 13·33 per cent. of the whole. Another Pennsylvania oil, from Franklin, on French Creek, of higher density (*Huile lourde*), gave him 10,672 units in all; and Ohio oil, dense and black, gave 10,399. The first sample, from Oil Creek, doubtless represents about the average of the crude oil of commerce, and is hence adopted as a basis for calculation. As the total heat of complete combustion of carbon as charcoal—according to the mean of the figures of ANDREWS, and of FAVRE and SILBERMANN—is 7,990 units per lb.; Pennsylvania oil, therefore, may be practically rated as having just 25 per cent. more heat in it per lb. than (chemically pure and perfectly anhydrous) wood charcoal, or (supposing ash and condensed gases present equivalent to 10 per cent. loss) 40 per cent. more than common charcoal. The theoretical powers of the best British coals per lb. are estimated to be between 14 and 16 lb. of steam; but the British Admiralty, in a long extended and elaborate series of experiments, found that the best actual result, from the best steam coals, was 9·5 lb. of steam per lb.; and not more than 8 lb. with ordinary coals. With perfect combustion and skilled handling we may safely adopt, as the actual steam value of petroleum, 16 lb. of water made into steam by 1 lb. of oil—equal to just 100 lb. of water per gallon; 4,400 lb. per barrel, or 528 gallons of water vaporised by 1 barrel of oil, from 212° Fahr.

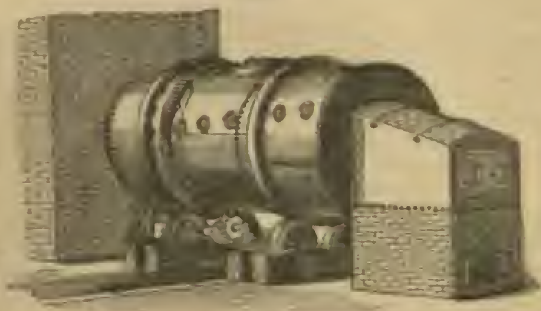
Furnaces, Puddling (COWPER'S), *&c.*—Mr. E. A. COWPER has invented an arrangement for heating the materials in furnaces (such as puddling, heating, melting, or boiling furnaces) by the use of gas in combination with very hot blast, heated by his patent hot-blast stoves (commonly known now as COWPER STOVES), so that the combustion being effected immediately on the materials shall be as effective as possible for heating the same, whilst full control over the character of the gases is retained, so that an oxidising flame, or a reducing flame, may be used as required. With such an arrangement, it is probable that iron might be puddled, with one-third of the coal, now wastefully used, in filling the whole furnace with flame of a sufficiently high temperature to effect the puddling operation. See HOT BLAST.

Furnace, Self-Stoking.—VICARS' self-stoking furnace is tolerably well known, but it is necessary for the information of such persons as are not acquainted with it to state that the fuel is fed on to the fire-bars by means of plungers, while the fire-bars themselves have a peculiar motion by which the fuel is gradually carried to the back of the grate. In the new furnace, this movement of the fire-bars is obtained by using only one cam shaft instead of two shafts, as in the old machines, and the mechanism for working the plungers has been simplified and made more compact. The most important modification, however, consists in the total abolition of the bridge and the reduction in the length of the fire-bars, which are only 2 ft. long. By the action of the bars, the incandescent fuel is carried forward and forced or pushed into the flue, where it forms a continuation of the fire, the whole of the flue becoming a combustion chamber, thus providing a larger space for the complete mixture of the products of combustion than is the case in the furnace of any ordinary internally-fired boiler, the radiant heat acts on the whole surface of the flue, and the escaping gases, instead of acting only on a portion of the upper part of the flue, are diffused and act upon the whole, thus, it is claimed, largely increasing the direct action of the fire on the boiler. A sheet-iron draught plate is placed across the end of the flue near the end of the grate, which can be readily removed when it is requisite to take out the ashes and clinkers. In many cases this plate is dispensed with, except when starting the fire, as it is found that the free passage of air through the incandescent mass in the flue

gives increased burning power, and consequently increased evaporation. Messrs Vicars have already altered about twenty of the furnaces erected by them, so far as the shortening of the fire-bars and the abolition of the bridge, retaining the old feeding mechanism, and in every instance the alteration is stated to be giving satisfaction.

Furnace, Revolving, Brückner's.—Brückner's revolving cylinders for roasting ores, &c., are now used at a number of the mills in Colorado and New Mexico, for the purpose of roasting and chloridising silver ores, with highly satisfactory results, even from those cylinders of small size, erected before the many improvements of recent date.

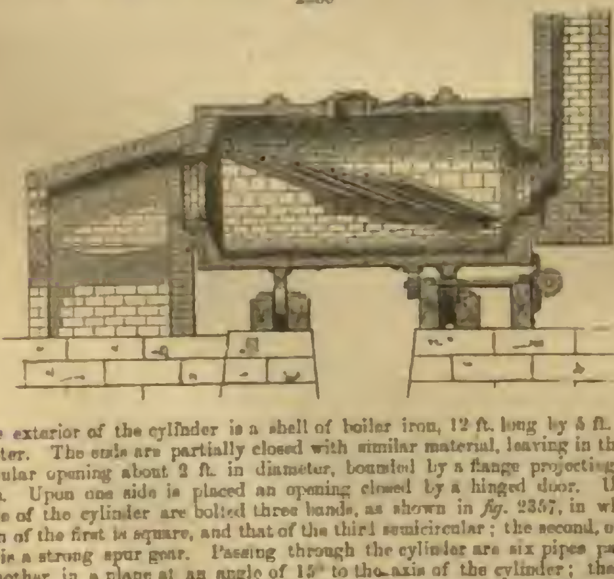
2357



As examples of the larger improved cylinders, reference can be made to those erected at the Tennessee Reduction Works, Silver City, Grant County, New Mexico, and those which were built, in 1871, at the celebrated Caribou Silver Mill and Mines, Colorado, a mining enterprise which has proved most satisfactory.

These cylinders, as now constructed, are shown in *fig.* 2357, an elevation in perspective, *fig.* 2358, a longitudinal, and *fig.* 2359 a transverse section. *Fig.* 2360 is a sketch of a mill, with Brückner's cylinder.

2358

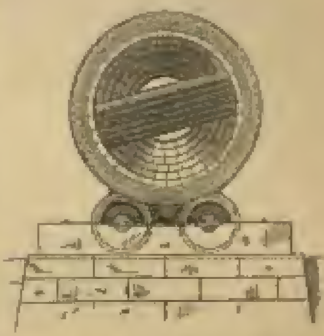


The exterior of the cylinder is a shell of boiler iron, 12 ft. long by 8 ft. 6 in. in diameter. The ends are partially closed with similar material, leaving in the centre a circular opening about 2 ft. in diameter, bounded by a flange projecting several inches. Upon one side is placed an opening closed by a hinged door. Upon the outside of the cylinder are bolted three bands, as shown in *fig.* 2357, in which the section of the first is square, and that of the third semicircular; the second, or middle band, is a strong spur gear. Passing through the cylinder are six pipes parallel to one another, in a plane at an angle of 15° to the axis of the cylinder; these pipes also lie in this plane at an angle of from 30° to 35° to the longitudinal axis of the plane, as shown in *fig.* 2358, where the internal arrangement of the cylinder is seen, a perforated diaphragm being formed through part of the cylinder by means of perfo-

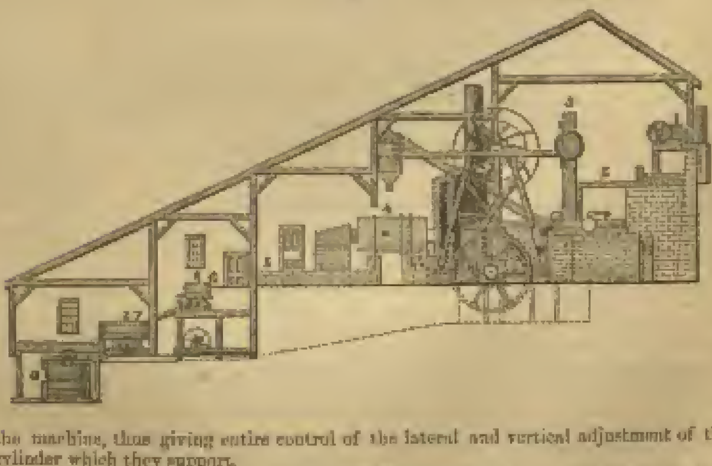
rated plates placed between the above-described pipes, the plates being held in place by longitudinal grooves upon these pipes.

The entire cylinder is lined with bricks (common building bricks have been found to answer the purpose very well), which are placed in the following manner:—The entire side of the cylinder is covered with one layer, laid flatwise, thus forming a lining about 2½ in. thick; there is an additional layer extending from each end of the cylinder about 16 in. to the point where the nearest pipe passes out; then additional concentric layers are added thereon, until the circle is contracted down to the size of the opening in the end, which is also lined, each layer falling short of the preceding one about 2 in., thus giving the end linings a conical form. The entire lining is laid in a mortar of one part fire-clay, two parts pulverized old fire-brick, and water, all thoroughly mixed and beaten. The cylinder is supported upon four large friction-rollers, two of which are grooved upon their periphery, to fit loosely the semicircular band, thus holding the cylinder longitudinally in place. The other two friction-rollers are made without a groove, and bear upon the square band, thus accommodating themselves to the expansion and contraction of the cylinder, or any irregularities of form. Rotary motion is given to the cylinder by means of a pinion placed under the cylinder and gearing into the spur-gear band. Upon the other end of the pinion-shaft are placed two bevel-wheels, into which gear two match-wheels. The latter are loose upon the driving-shaft, standing at right angles to the pinion-shaft, and either of these wheels can be attached to the driving-shaft, thus communicating the speed of revolution to one or the other of the bevel-gear as may be desired. Inasmuch as by wear, or settling, the axis of the cylinder may possibly be thrown out of the proper line, the following means of adjustment are provided, but not shown in any of the figures, viz., each journal-box of the friction-rollers is held in position by adjusting-screws, by which it can be moved horizontally to or from the centre line of

2359



2360



the machine, thus giving entire control of the lateral and vertical adjustment of the cylinder which they support.

The circular flange of one end of the cylinder loosely projects into a fire-box, best seen in section to the left of *fig.* 2358. The other end projects into an opening communicating with dust-chambers and a chimney. There is placed in the bottom of the flue a shoe projecting into the cylinder, which catches such dust as may fall back, and returns it into the cylinder in lieu of allowing it to escape through the crevice between the cylinder-flange and opening into the flue. A door is placed in the flue opposite

the opening, through which the interior of the cylinder and its contents can be readily examined at any time.

Method of Operating the Cylinder with Refractory Silver Ores.—A fire having been kindled in the fire-box, the cylinder is allowed to slowly revolve until heated to a dull-red, and is then brought to rest with the door on top. In this position about 4,000 lb. of pulverised ore and 200 to 400 lb. of salt are introduced; the door is closed and securely fastened, and the cylinders are made to revolve at the slower speed of from one-half to one turn per minute. The fire is so regulated that after an hour's time the sulphur contained in the ore commences to burn, the ore in the cylinder being retained at a dull-red for some time. (In ores containing a large amount of sulphur, little or no additional fuel is required for desulphurisation.) During the whole of this and the subsequent operation, the inclined perforated diaphragm causes the heated ore to travel alternately backward and forward the entire length of the cylinder, also sifting it through the flame, thus insuring a uniform heating, mixing, and exposure to chemical action.

The diaphragm, in the meantime, is protected from destructive action of heat by the cooling effect of the external air circulating through the pipes, and from corrosion by the formation of a basic scale, or coating, resulting from reaction of the iron pulp, &c.

The desulphurisation being completed, the heat is gradually augmented to a full red. The pulp soon assumes a spongy appearance, technically known as 'woolly,' in consequence of the double decomposition of the sulphates (formed during desulphurising) and salt (chloride of sodium), liberating chlorine gas, &c. After an hour's time, or as soon as a sample taken from the cylinder evolves the odour of chlorine uncontaminated with that of sulphurous acid, which indicates that the chlorination is complete, the door in the cylinder is opened, and the cylinder revolved by the more rapid-moving gear, and the chloridised ore is quickly discharged, being received into a car, chute, or other conveyer, according to the construction of the mill.

The door in the back of the flue furnishes a ready means for sampling and examining the condition of the ore in its progressive stages, and in some cases the salt is not added to the ore until subsequent to desulphurising, in which case this flue door is conveniently used.

Other Uses of the Cylinder.—The cylinder has been found to give excellent results in roasting the compound auriferous pyritic ores to be treated by the PLATTNER process, in which case a small quantity of charcoal is subsequently introduced to the charge, so as to facilitate the decomposition of the resultant sulphate of copper. This form of cylinder is undoubtedly well calculated for the manufacture of soda from cryolite, roasting cement, plaster of Paris, ores of zinc, lead, copper, &c. In a word, it is admirably adapted to most of the roasting and reverberating furnace operations.

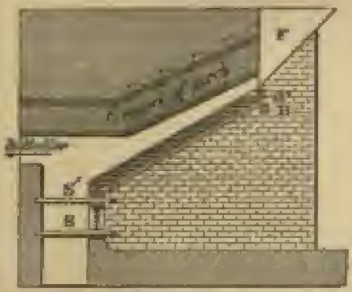
Cost, Weight, and Capacity of the BRÜCKNER *Cylinders.*—The cost of a cylinder, including its supporting and rotating machinery, iron work for fire-box, bolts for foundations, and all royalties on patents, is about $2,100. The total weight of the foregoing parts is 16,000 lb. The placing of the foundation and erection of brick-work, for fire-box, cylinder linings, and dust-chambers, will vary greatly according to local circumstances. The capacity of a cylinder in twenty-four hours is, as reported, from 8 to 10 tons (in very refractory ores the daily average would be less), the chloridising being up to 96 per cent. J. M. LOCKE, C.E., Cincinnati.—*The Transactions of the American Institute of Mining Engineers*, vol. ii.

Furnace, STETEFELDT.—This is the only desulphurising furnace which appears to claim notice. The one used at Reno, near Virginia, for desulphurising and chlorodising the ore, consists of a shaft 20 ft. high by 3 or 4 ft. square. At its base there are two fireplaces, in opposite sides, with short flues leading into the stacks. The ore having been mixed with 3 to 6 per cent. of salt, is crushed under stamps and passed through No. 40 screens. This finely pulverised ore is fed in a continuous stream by machinery from the top of the shaft. Just below the top of the shaft is a flue for the escape of the gases, leading into dust-chambers, where any portion of the fine material carried up by the draught may deposit. The main shaft at the end of the dust chambers is 40 ft. high. As the fine ore descends, mixed with salt, against the current of hot air ascending in the shaft, it becomes chloridised, giving off sulphurous and sulphuric acid; every atom of the ore being exposed to oxidising and chlorodising influences. The furnace is said to perform its work with less cost for fuel, labour, and salt, than the ordinary reverberatory, one furnace treating 20 tons in a day, with the labour of eight men. The fuel used is two cords of wood a day, while the ten reverberatories would require five times the quantity, and the saving of salt is one-half. The bullion produced is larger and richer, and the cost of treatment only about 26*s*. per ton.

The loss on the Colorado ores has been pretty well ascertained: it is about 30 per cent. Of the quantity saved, 5 per cent. is obtained in the battery and appliances, and 15 per cent. by concentration and treatment of tailings.

Furnace, Step.—This furnace is one of several plans which have been introduced for the purpose of regulating the supply of coal to the quantity of air admitted, so as to secure, as far as possible, complete combustion. F (*figs.* 2361 and 2362) is the hopper into which the fuel is thrown; F B is the arrangement of steps down which

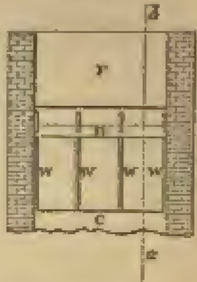
2361



LONGITUDINAL SECTION
According to a b

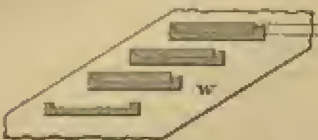
FEET

2362

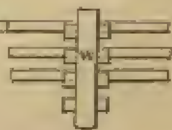


PART PLAN
Showing Checks W.

2363



2364



CHECKS W. WITH STEPS

FEET

the coal falls, becoming ignited in its progress, and being supplied with air through an air passage at B, and through the fire bars at s s. The intense flame produced at the bottom of the steps is conveyed under the boiler through the opening marked. *Figs.* 2363 and 2364 give the plans of the step. Furnaces of this description will be more fully described in relation to their use for burning brown coal in Bohemia under Treppen-Rost, *which see.*

FUSIL OIL, to detect in spirit. See Methylated Spirit.

G

GALLIUM. On August 27, 1875, M. Lecoq de Boisbaudran observed—when making a spectroscopic examination of a blende ore from the mine of Pierrefitte, in the valley of Argelès, department of the Pyrenees—two peculiar bands, both situated in the violet ray, which were sufficiently defined to indicate the existence of a new metal.

On December 6, 1875, M. Wurtz placed before the Academy of Sciences some specimens of gallium obtained by M. Lecoq in the metallic state, which were obtained by the following process:—

Sulphate of gallium, dissolved in ammoniacal water, was subjected to the action of the voltaic current. Metallic gallium was deposited on a plate of platinum, which served as the negative electrode. The specimen laid before the Academy weighed

0·0034 gramme, and was deposited in 6 hours and 40 minutes upon a square of about 123 square millimètres. The particles detached from the electrode by the action of the burnisher had already acquired a distinct metallic lustre; a polish of more marked character was got by compression under the agate burnisher. In this case the gallium came out as a bright white metal, to which platinum is inferior in colour. When the gallium salt is slowly decomposed by a well-regulated electric current, the metal is deposited a beautiful dead surface, silvery white, finely granulated, and relieved with a large number of tiny, shining points, the crystalline structure of which is revealed under the microscope.

Under the influence of hydrochloric acid in the cold, water is decomposed by gallium, and the reaction, which is much more intense with heat, is accompanied by a brisk disengagement of hydrogen.

The description given by M. Lecoq de Boisbaudran is as follows:—

'After trials rendered long and laborious by the variety of the material, I have prepared salts of gallium sufficiently pure to give in the spectroscope magnificent spectra of gallium, with but feeble rays of zinc, Zn α 144·62, Zn λ 150·05. In examining the properties of the pure salts of gallium, I have noticed certain differences from those which present themselves when the gallium is mixed with much zinc. They are as follows:—On a mixture of gallium with zinc with potassium ferrocyanide, gallium reacts similar to zinc. To a dilute solution of the chlorides was added $\frac{1}{4}$ the its volume of HCl concentrated, then a slight excess of yellow prussiate, and finally, four times its volume of water. All the gallium and zinc were precipitated. These ferrocyanides washed with strong HCl, and decomposed with ammonia sulphydrate. The chlorhydric solutions of these sulphides gave brilliant rays of Zn and Ga. A strip of cadmium precipitated nothing from a solution of the chlorides of Zn and Ga, even on ebullition. When fractionally precipitated by carbonate of soda and boiled, a $ZnCl^2$ containing the gallium is thrown down. This last metal is more abundant in the first deposits; this separation is so distinct that while one gives the rays of gallium much more brilliant than those of zinc, the other (following) gives but a feeble ray of Ga α 417, and a bright Zn spectra. If acetic acid be added to an ammoniacal solution of the sulphates or chlorides of Ga and Zn, nearly all the Ga is precipitated in the form of white gelatinous flocks—ebullition with a notable excess of $C^4H^4O^4$ fails to redissolve the precipitate. The reactions with pure salts of gallium:—(1) The electric spectra of gallium chloride, a little concentrated, is very brilliant. The ray 417 is much brighter than that of 404. I have not noticed other rays attributable to gallium; there is certainly none of noticeable intensity. The colour of the spark striking the gallium chloride is light violet. (2) In the gas flame I have obtained the Ga ray α 417, though but feeble and fugitive, even with a salt which gave brilliant electric spectra. (3) The chlorides and sulphates of Ga are precipitated by NH^3, but redissolve mostly in an excess of NH^3; if to that remaining HCl and NH^3 be added, all will go into solution. (4) An ammoniacal solution of sulphate or chloride of Ga is precipitated, cold or hot, by an excess of acetic acid—a very dilute solution is necessary. (5) The chloride and sulphate Ga are not precipitated in the cold by acid acetate of ammonia, but will do so on boiling. (6) Sulphate of Ga, evaporated and heated until nearly all the white fumes of the sulphuric acid pass off, does not lose its solubility in water. (7) The sulphate of Ga is soluble in alcohol of $\frac{[illegible]}{100}$. (8) An ammonia gallic alum may be formed as in No. 3. (9) The alum of Ga is soluble in cold water, but when heated it is decomposed, and the liquid becomes cloudy. (10) This alum is not decomposed when heated with water in the presence of acetic acid. (11) This alum crystallises easily in cubes and octahedrons, presenting exactly the appearance of ordinary alums; its solution, evaporated under the microscope, follows also the characteristic behaviour of known alums. (12) The crystals of Ga alum do not act on polarised light. (13) A small crystal of Ga alum placed a short time under water, and then in a slightly saturated solution of aluminoammoniacal alum, enlarged itself, and determined the crystallisation of the liquor. (14) With an excess of ammonia, the Ga alum acts as the other salts of Ga, a part of the oxide is precipitated, and the rest goes into solution. (15) A strongly acid solution of Ga^2Cl^6 is precipitated by the yellow prussiate: see No. 4. (16) The ammoniacal solution of the sulphate of Ga is decomposed by the voltaic current. Metallic Ga is precipitated on the platinum strip, serving the negative electrode. The positive electrode is covered with a slight white film soluble in NH^3: see No. 5. (17) The electro-deposit of Ga adheres strongly, is hard, and burnishes badly by friction with an agate burnisher, but with strong compression under the burnisher a better polish is obtained, having the appearance of platinum. With a well-regulated battery a crystalline deposit is formed, presenting a beautiful silvery white surface. (18) Ga, deposited on a strip of platinum, does not oxidise during the washings by hot or cold water, nor during the drying at 200° in a current of air; it decomposes water acidu-

lated with HCl in the cold, but more rapidly when heated, with a brisk disengagement of hydrogen. The salts of gallium used for these experiments were obtained from the blende of Pierrefitte, but the presence of this new metal has been detected in other minerals of zinc, and especially in the transparent blende of Santander—and I have no doubt it exists in all the blendes. The Ga that I extracted from blendes came really from them and not from the zinc (Vieille Montagne) employed for the precipitations, as I could not obtain traces of Ga in large quantities of this zinc. My later researches have confirmed the rarity of Ga in the blendes. The extreme sensibility of the spectrum reactions have led me to too highly estimate the quantities obtained. I do not think I had more than $\frac{1}{100}$ milligramme for my first researches. If, as I suppose, there is not an error in the nature of my alum of Ga, the existence of this salt fixes the atomicity of this new element, and attributes to its oxide the same function as that of aluminium, and the oxide of gallium should be written Ga^2O^3.'

Gallium, Extraction of.—M. Lecoq thus describes his latest method:—'The blende is dissolved in *aqua regia*, and pieces of sheet zinc are placed in the liquid and withdrawn when the escape of hydrogen has greatly subsided, but is still perceptible. In this manner is separated the greater part of Cu, Pb, Cd, Tr, Tl, Ag, Hg, Se, As, &c. To the clear liquid zinc is added in large excess, and it is boiled for several hours, when an abundant precipitate is formed containing alumina, subsalts of zinc, and gallium. This precipitate is redissolved by hydrochloric acid, and the solution boiled again with zinc. All the gallium present is thus concentrated in a liquid of small bulk. The last gelatinous precipitate is dissolved in hydrochloric acid, acetate of ammonia is added, and the solution treated with sulphuretted hydrogen. This operation is repeated for the complete removal of the alumina. The hydrochloric solution of the white sulphides is precipitated fractionally with carbonate of soda, when the gallium is found concentrated in the first portion deposited. The spectroscope indicates the point at which it is necessary to stop. To complete the separation of the zinc, the oxide of gallium is dissolved in sulphuric acid, and then supersaturated with ammonia in excess. The gallium which remains in the ammoniacal solution may be expelled by boiling to expel free ammonia, destroying the ammoniacal salts with *aqua regia*, and fractional precipitation with carbonate of soda. The pure oxide of gallium precipitated by ammonia is dissolved in potassa and submitted to electrolysis, when gallium is deposited on the negative platinum electrode. The positive electrode, likewise of platinum, should be larger than the negative. Five or six Bunsen elements are sufficient to decompose 20 to 30 c.c. of the concentrated solution. On placing the negative electrode in cold water and bending it, the gallium is easily detached. The author has sought for gallium in the following substances:—

'A. *Rich Substances.*—Black blende from Bensberg (specimens sent by the VIEILLE MONTAGNE MINING COMPANY); yellow transparent blende from Asturias; brown blende from Pierrefitte (Pyrenees).

'B. *Rather Poor Substances.*—Powdered zinc from the Vieille Montagne; zinc dross from Corphalie.

'C. *Very Poor Substances.*—Yellow opaque blende from Mandesse (Gard); brown blende from Sweden; black brown blende from Schwarzenberg, in Silesia; blende in rods from Nouvelle Montagne. No gallium was found in the following: ribbon blende from Vieille Montagne; tuts from Corphalie; galenas from Pierrefitte and elsewhere; metallic zinc from Vieille Montagne, as used at Cognac for building purposes; calamines from Sardinia and Le Gard; commercial hydrochloric and nitric acids.'—*Chemical News*, June 2.

M. LECOQ DE BOISBAUDRAN presented the Academy of Sciences, at the séance of November 27, 1876, with crystals of metallic gallium. The value found for the angles appears to lead to a clino-rhombic form.

GALLS. See GALL NUTS, vol. ii. p. 531.

Imported in 1875.

	Cwt.	Value £
From Turkey	6,789	17,786
" Persia	2,480	6,617
" China	13,714	29,782
" British India—Bombay and Scinde	3,746	6,179
" other Countries	1,432	3,051
Total	28,162	63,359

GAMBIER. (Vol. ii. p. 534.)

Importations in 1875.

	Tons	£
From Straits Settlements	22,299	573,523
„ other Countries	775	27,582
Total	23,074	601,105

GARNIERITE. An ore of nickel. See NICKEL.

GAS, AMMONIA IMPURITY. See AMMONIA IMPURITY IN GAS.

GAS BURNER (BUNSEN). At a lecture given by Mr. J. WALLACE, of Newcastle-upon-Tyne, before the Society for the Promotion of Scientific Industry at Manchester, he described his improvement on the well-known BUNSEN burner. The flame of the BUNSEN burner, almost without colour, was known to contain a hollow space within it for about half its length. This hollow space, which the BUNSEN flame had in common with the candle-flame, was considered an essential part of its structure. Mr. WALLACE, during a series of experiments made to ascertain the amount of air that might safely be mixed with coal-gas previous to combustion, observed, that as the proportion of air was increased the hollow space became smaller, the whole flame contracted, and the temperature became more intense. The surface of the conical space changed from a leaden blue colour to an intensely brilliant emerald green, which sparkled and crackled like the flame of a blow-pipe, until (as the proportion of air still continued to increase) the hollow space disappeared altogether, and the gas and air exploded in the BUNSEN tube.

It was thus apparent that the hollow space or zone of no combustion depended entirely on the amount of air which was mixed with the gas previous to combustion, and it only remained to construct a burner in which the gas jet should be able to induce the extra quantity of air, and the burner itself be so arranged that the tendency to explode or light within should be prevented. It may here be noted that a much greater proportion of air must be pre-admixed to obtain a good flame from a large burner than from a small one, because the area of the flame increases at a much greater rate than its circumference. The remainder of the air, which makes up the total combining quantity, is combined with the gas *during* combustion, and appears only to unite at the lower part of the flame; the upper part being enveloped and cut off, so to speak, by its own products.

Six and one-third volumes is, roughly, the total amount of air which will combine with Newcastle coal-gas, and of this $1\frac{1}{2}$ is as much as may with any advantage be mixed previous to combustion in a $\frac{1}{2}$-inch burner. The remainder combines at the flame. A cylindrical cap of finely perforated iron plate was fitted on to a burner-tube 1 inch in diameter, and made adjustable to various heights. When raised to $\frac{3}{8}$ inch, gas was burned above it at the rate of 20 feet per hour, with a flame which was solid to the centre, each hole in the cap being covered by a bright green bead showing where combustion began. A 2-inch tube was next fitted up with three jets at the bottom, capable of passing 40 feet per hour at $1\frac{3}{4}$-inch pressure. When lighted and adjusted the flame proved to be as complete as the previous ones, and the proportion of air pre-admixed, when measured from a test holder, was $4\frac{6}{10}$ths volumes. A platinum wire stretched across the flame $\frac{1}{4}$ inch above the cap became instantly white-hot for a distance of 4 inches, and the colour gave no indication of any difference of temperature in any part enveloped in the flames. When the air was interrupted at the base of the burner a large hollow space immediately appeared above the cap, and the wire cooled to blackness. On again admitting the air the wire was once more incandescent. The green beads, when examined by the spectroscope, give the spectrum of carbonic oxide, and they only appear in a flame which burns in the most complete manner.

The inventor of the new burner, in testing it against an ordinary light-giving burner, realised an advantage of 25 per cent. in favour of the former, and as it may with safety be turned low without lighting within, it offers at least one solution to the very difficult problem of burning coal-gas in quantity. It is already in use for many important purposes, such as heating stoves, tempering tools, warming green-houses and baths, and raising steam for an engine to drive printing-machines.

GAS, DETECTION OF VARIATIONS OF PRESSURE OF. See PRESSURE OF GAS.

GASES ENCLOSED IN COAL. See COAL, GASES ENCLOSED IN.

GASES FROM COAL. See COAL, GASES FROM.

GAS IN COOKING. The use of gas in cooking in Germany has been pronounced to be a luxury. According to Professor MEIDINGER, a family of 4 persons

will consume for this purpose 5·5 lb. of wood and 11 lb. of coal per day; the corresponding quantity of gas, being 233 cubic feet, would cost $6\frac{1}{4}$ times as much as its equivalent quantity of wood and coal. The enormous difference between the amount of heat given out by the coal, and that effective for cooking, reduces the costliness of gas. Meidinger puts the effective heat in ordinary kitchen ranges at about $\frac{1}{25}$th of the total heat given out by the coal. An experiment was made with a gas-stove constructed to supply a household of 6 persons; a separate burner kept 5·5 gallons of water at a mean temperature of 122° Fahr., consuming, night and day, between January 1 and April 1, 4,000 cubic feet, or 16,000 cubic feet per year, at a cost of about 2l. 17s. The mean daily consumption, at 44·6 cubic feet, cost about 2½d.

Considerable saving was effected by using pots with double sides and lids, the inner vessel being thus surrounded with a jacket of hot air. M. Meidinger calculates that for a pot of tin-plate, 9·5 inches in diameter and 7·9 inches in height, the use of a double wall, inclosing a layer of air 0·8 inch thick, would reduce the loss of heat by radiation to one-third of that lost from a single-walled vessel. So thick an air-layer being inconvenient, one having a mean thickness of 0·4 inch was used, being calculated to reduce the loss of heat by radiation, during boiling, to about one-half of that lost from a single-walled vessel. The inclosed air, at a temperature of 176° Fahr., would exert an additional pressure of ¼ atmosphere; which pressure, however, vessels of ordinary tin-plate, and with soldered edges, are well able to stand.—C. Wohly, *Journal für Gasbeleuchtung*, No. 12, 1875, pp. 430–447.

Gas, its Illuminating Power.—A method of testing the illuminating power of gas has been devised by Dr. C. M. Siemens. The invention is based on the discovery by M. Sale that selenium is a conductor of electricity just in proportion as it is exposed to light, and that the luminous portions of the spectrum are precisely those which render selenium most conductive. The conductive power of selenium is, however, slight and uncertain, and the destructive action of calorific rays upon it is considerable. But Dr. Siemens found that by raising amorphous selenium almost to a fusing point of heat, and then slowly cooling, he obtained crystalline structures which were better conductors of electricity, and which, while less susceptible to the calorific rays of a flame, were, curiously enough, far more sensitive to light. He adjusted a small particle of this crystalline selenium in the circuit of a galvanic battery, and connected the whole with a galvanometer, the needle of which indicated with the nicest precision the increase or diminution of the electric current through the selenium. This current was found to be affected by the slightest gradations of even the feeblest jets of flame, the light of which was allowed to fall upon this conductor, which, therefore, presented a test far more delicate and reliable than that afforded by the ordinary photometer. A light of a specific intensity being adopted as a standard, any other light might be measured by placing it at such a distance as would produce the same reading on the galvanometer, and its strength would then be a matter of arithmetic based on the well-known rule that the intensity of a light on a given object varies inversely as the square of the distance.

GAS, NATURAL, *Analysis of*, by Professor Sadtler, of the University of Pennsylvania:—

	Burns's Well	Leechburg Well	Harvey's Well
Carbonic acid	·34	·35	·66
Carbonic oxide	traces	·26	traces
Hydrocarbons—*illuminating*	—	·56	—
Hydrogen	6·10	4·79	13·50
Marsh gas, CH^4	75·44	89·65	80·11
Ethyl hydride, C^2H^6	18·12	4·39	5·72
Propyl hydride, C^3H^8	traces	traces	traces
Oxygen	—	—	—
Nitrogen	—	—	—
	100·00	100·00	99·99

Specific Gravity of the Gases.

Burns's Well	·6148
Leechburg gas	·5580
Harvey's Well	·5119

CALORIFIC CALCULATIONS.

Calorific Power in Heat-units, Centigrade.

Burns's Well	14·211 units
Leechburg gas	14·105 ,,
Harvey's Well	16·097 ,,

Calorific Intensity (theoretical Temperature Centigrade, attainable by Combustion in Air).

Burns's Well	2,745° C.
Leechburg gas	2,749° C.
Harvey's Well	2,703° C.

American Gas Manufacturer.

Gas from Petroleum and Anthracite.—This process, the invention of Mr. T. S. C. Lowe, of Norristown, Pa., consists in producing from anthracite and decomposed steam, a gas of a very high heating power, which for illuminating purposes is enriched with petroleum vapour. The anthracite is charged in a small cupola, say 3½ ft. in diameter, to a depth, kept constant, of from 3 to 4 ft. When fairly ignited, the base is closed, and superheated steam is admitted a little above the grate bars; the steam is decomposed, and the product is a mixture of hydrogen and carbonic oxide. For illuminating gas a small jet of crude petroleum is directed on to the surface of the burning coal, the gases from both of which thus become mixed; but a more thorough admixture is insured by passing them through a fire-brick cellular structure. The charge used in some works where this system is adopted has been about 280 gallons of crude petroleum, and 3,600 lb. of anthracite, for the production of 70,000 cubic ft. of illuminating gas, the cost amounting to from 56 to 60 cents per 1,000 ft. The system has been tried two years, and the cold of the past two winters at Phœnixville has not affected the gas, and has proved the 'fixedness' of the product.—*The Engineering and Mining Journal* (New York), July 31, 1875, p. 97.

GELOSE. A gelatinous matter obtained from an alga growing in Cochin China, which is used for the same purposes as gum.

GENISTA. (*The Broom.*) In Calabria and in Tuscany a variety of the genista (*Spartium junceum*), Spanish broom, is used for cordage and coarse baggings. It is said to be cheaper than hemp and much stronger. In some parts of France this broom is used for the same purpose. The *Spartium scoparium*, the common broom, furnishes an abundance of fibre, but prejudice in favour of the Spanish broom has prevented any satisfactory trial of its strength.

GINGELLY OIL. A name for the oil from the sesamum seed. See SESAMUM.

GLASS. M. EUG. PELIGOT, in a memoir presented to the Académie des Sciences on December 11, 1876, *Sur la composition du verre et du cristal chez les anciens*, gives the following as the composition of some of the glasses examined, viz.:—

Silica	66·7	66·0	67·4	70·9	69·4	69·4
Lime	5·8	7·2	2·7	7·9	6·4	7·1
Alumina, Oxides of Iron and Manganese . .	2·8	3·0	5·4	4·5	2·9	2·8
Soda or Potash . . .	24·7	23·8	24·5	16·7	21·3	20·7

These glasses, PELIGOT states, were probably of the eleventh century. In all of them he found both soda and potash. He therefore supposes that the ashes of marine plants had been usually employed.

'*Cristal*,' of the French, the highly refractive lead flint glass of the English, is thought by M. PELIGOT to have been made at a very early period. He writes: 'Je citerai en première ligne FOUGEROUX DE BONDAROY, membre de l'Académie Royale des Sciences, qui a publié dans les mémoires de cette compagnie, en 1787, un travail concernant l'examen d'un verre désigné sur le nom de *miroir de Virgile*.

'Entre les raretés et les richesses de différentes espèces qui font partie du trésor de SAINT-DENYS, en France, on conservait une substance transparente, de forme ovale, longue de 14 pouces dans son plus grand diamètre, de 12 pouces dans son petit, et épaisse d'un bon pouce, à laquelle on a laissé le nom vulgaire de *miroir de Virgile*; le poids total de ce morceau était d'environ 20 livres. Sans prétendre fixer à ce verre une antiquité aussi reculée, on assure qu'il est depuis les premiers temps que ce trésor a été établi dans cette maison.

'Le verre est homogène, d'un vert mêlé avec du jaune; il est poli sur les deux

surfaces; mais les bords semblent n'avoir pas été usés et conservent l'empreinte du moule, qui lui a donné la forme; 1 pouce cube pèse 1600 grains; le pouce cube du verre des vulcans pèse 800 grains.'

This 'cristal' was carefully examined by M. Eug. Peligot, who states that it is not 'du cristal proprement,' but it is a simple silicate of lead, produced in the muffle similar to the imitations of precious stones made by the ancients of the time of Pliny, and for the Jews in the middle ages.—See Art. *du Verre*, by M. Allut, *Encyclopédie Méthodique*, vol. vii.; Art. *de la Verrerie de Néri*, p. 133; and *Comptes Rendus* for December 11, 1876.

GLASS, RED. M. Haccamay thus describes the mode by which the French rose and red shades of glass are produced. A certain quantity of auriferous glass is prepared beforehand, and run in thin plates, and fragments of these plates are used by the glass-blower to fuse upon his work, and thus give it a superficial colouration. It often happens that one and the same composition of auriferous crystal gives plates of very different shades, some colourless, others tinged more or less deeply with rose and red, and some almost black; these differences being due to two causes—namely, the temperature of the furnace in which the fusion has been effected, and the temperature of the mould into which the melted metal is run. For light-coloured plates the temperature of the furnace is made low, and the mould very cold; blue plates are sometimes produced under the same circumstances, which, if reheated, take the normal colour, as do also the colourless and very pale rose glasses. The curious facts thus developed, in regard to the process in question and its results, render it probable that the colouring matter is neither a salt nor an oxide, but a simple body. Crystal coloured with gold is probably therefore merely vitreous matter, holding metallic gold in a state of very fine subdivision. It is stated that on examining the red plates, it is easy to recognise in the mass a multitude of most brilliant specks of metallic gold, forming a sort of aventurine. This fact was observed by Dr. Faraday long since.—*Bulletin de la Société d'Encouragement.*

GLASS, TOUGHENED. A glass possessing a peculiar toughness has, within the last two or three years, excited much attention. It appears to be glass in a condition somewhat analogous to the Réaumur porcelain, which was a devitrification of glass by prolonged exposure to heat. It has also something in common with the well-known Prince Rupert drop and the Bologna phial. It has been stated that several years since, M. François de la Bastie, a French engineer, after long and patient investigation into the subject, discovered a simple means of rendering glass practically unbrittle, and at the same time of preserving its transparency. There were many delicate conditions involved in the process by which he obtained this result, but on endeavouring to repeat the successful experiment he failed signally. If dipped in water the hot glass invariably broke. Fatty matters perfectly purified, and virgin oils free of all admixture, gave good results, the temperature employed varying from 150° to 300°. Glycerine, whether pure or mixed with fats, it was found could not be advantageously used. For two years more M. de la Bastie strove without avail to re-discover the secret of his success. At length he succeeded in so doing, and has since been engaged in perfecting his invention and in developing a laboratory experiment into practical working. The process of conversion in the main is a very simple one, so simple that it seems singular it was never thought of before. Broadly stated, it consists in heating the glass at a certain temperature and plunging it while hot into a bath consisting of a heated oleaginous compound. There are, however, many conditions in connection with the details of the process upon which a satisfactory result depends, and the neglect of any, even in a slight degree, constitutes the difference between success and failure. Thus, the glass may be underheated and will not be susceptible to the effect of the bath, or it may be overheated and it will then lose its shape, or, again, it may be rightly heated and yet be spoilt in the course of transference to the bath. Moreover, the oleaginous constituents of the bath and their temperature have an important bearing upon the ultimate result. These and numerous other points of detail have all been satisfactorily settled by M. de la Bastie, who has designed furnaces and baths by means of which this toughening process can be carried out practically without fear of mischance. The time occupied in the actual process of tempering is merely nominal, for directly the articles are brought to the required temperature they are plunged into the bath and may be instantly withdrawn. The cost of tempering, too, is stated to be very small.

At the annual meeting of the *Société de Secours des Amis des Sciences* in the amphitheatre of the Sorbonne, M. Victor de Luynes gave many important explanations of this manufacture. He explained the expansion and compression of the exterior and interior parts caused by immersing glass heated to a certain temperature in an oleaginous bath, and he gave some highly interesting proofs of the success of the process. Thus he applied some vigorous blows with a hammer to a piece of glass

which in its ordinary condition must have been broken into fragments, but which sustained this violence without being any the worse for it. A small tube of thin twisted glass being fastened in a vice, he endeavoured to break off the extremity of it with a pair of pincers, but it was only after several attempts and by dint of much evident muscular exertion that he succeeded in doing so. A furnace, moreover, was brought into the hall, and a number of small globes and pieces of sheet glass were submitted to the toughening process. M. DE LUYNES then threw some of them on the floor to show that they could bear the shock. The globes were fastened by strings to staves of wood at various heights, and an assistant mounting a ladder and setting fire to the string, they fell on the table with considerable force, thence rebounding on the floor, but only one or two of them were fractured, and those only when falling four or five yards. The assistant also mounted on a curved plate of glass placed on the table so as to represent an arc of a circle, but though the portion of the glass on which he stood was an inch or two above the table it bore the whole weight of his body. A similar experiment with much thinner glass was not so successful, but M. DE LUYNES stated that it had previously borne the strain, though it had been necessary for the assistant to mount upon it somewhat carefully so as to equalise the pressure as much as possible. Of course M. DE LA BASTIE, as M. DE LUYNES explained, does not pretend that glass thus tempered is absolutely free from danger of breakage, but he claims that it will bear 80 or 100 times the strain of ordinary glass. The glass, moreover, it is stated, can be cut under certain conditions as easily as common glass.

A lecture was delivered by Mr. PERRY F. NURSEY, C.E., before the Society of Arts, in which he fully explained the process of M. DE LA BASTIE. At the conclusion of the paper Mr. NURSEY experimented with toughened and untoughened glass articles, showing the infinitely greater resistance to the force of impact possessed by the former over the latter. A square of ordinary plate glass, 6 in. by 5 in. by ¼ in. thick, was broken by a weight of 4 ozs. falling on it from a height of 12 in. The same weight was then dropped upon a square of toughened glass of similar dimensions from a height of 10 ft., but without breaking the glass. A weight of 8 ozs. was then substituted with similar results. Mr. NURSEY then threw the weight several times on the glass with great force without breaking it; but he ultimately smashed it with a hammer. Watch glasses, glass plates, coloured and plain, were then put to the test, by being thrown violently on the bare floor without damage. One plate was dropped from a height of 5 ft. on to an iron grating, and rebounded into the air uninjured.

The process as carried out in New York is thus described:—The glass, after being run from the furnaces and moulded as usual, instead of being put into annealing pans, is immersed into a hot bath, consisting of 3 parts flaxseed oil and 1 part of tallow. The bath stands at about 320°; and after remaining in this, the ware is removed to a second and similar bath, by which it is cooled down to about 200°. Finally, the pieces are immersed in a water bath, and then dipped into a quantity of ordinary refined burning oil. They are then cleaned, ready for packing, with plaster of Paris powder. The work is but in its infancy, and but one small furnace is used in the present experiments. Improvements will doubtless be made by which the cleaning can be done more rapidly than by the powdered plaster, probably some chemical being used for this purpose. It is supposed that the oil works into the pores of the hot glass, and thus toughens it. Great care has to be exercised in the final cooling by water, as too long a contact with the air in changing from one bath to another makes the ware crack. Articles cooled entirely in oil retain the oil on the surface, but are thus rendered stronger than otherwise. This new process is very much employed in the manufacture of lamp chimneys, though they have the disadvantage of flying into very small pieces, and with violence, when they do break, which sometimes does occur.

M. DE LA BASTIE's experimental researches were based on the theory that the fragility of glass is caused by the weakness of the cohesion of its molecules, and that consequently, if this cohesion can be increased, the strength of the material will be augmented in proportion. At first, M. DE LA BASTIE tried to obtain the desired result by forcibly compressing the glass while in a fluid or soft condition, but without success; and it was not till after some years of experiment that he discovered the method of tempering it which forms the subject of his patent. Dropping fused or heated glass into water produces a violent contraction of its particles, which are thrown into a state of unstable equilibrium, so that the least shock causes it to break up into innumerable pieces. By dipping the glass into oil or other liquid capable of being heated to a temperature considerably above that of water, it is found that it is not only hardened, but tempered, so to speak—*i.e.* it has lost its brittleness. The conditions for the tempering process are two; the glass must be at a certain tempera-

ture, and also the liquid in the dipping bath. The latter, which may consist of oils, grease, wax, resin, tar, or pitch, must be capable of being raised to a comparatively high temperature without boiling, and the heat at which the glass is found to be best fitted for the tempering process is that which just precedes the soft condition.

We have witnessed the actual manufacture, and the melted mixture of fat and oil was not so hot but that the finger could be dipped into it without inconvenience.

A considerable degree of uncertainty attends this process: sometimes very great toughness is obtained, and, as stated above, the glass bears a blow without any sign of a fracture. In other cases we have seen a comparatively slight blow shiver it into fragments.

M. E. Girouard remarks, in *Les Mondes* for July 8, 1875, that the tempered glass sometimes bursts into a great number of fragments when struck very slightly. This, he thinks, happens chiefly when the glass article has been struck a great many times, and when it is as it were trembling under the action of a succession of blows or shocks. Girouard thinks, and perhaps he is justified in this, that the process of tempering may be applied also to enamel, earthenware, &c.

It is a fact that half a century since it was a common practice to place newly purchased glasses, cups, &c., in a pan of cold water, which was then very gradually raised to the boiling point. It was thought that this treatment rendered them less brittle. When the editor was an apprentice, he well remembers treating lamp glasses in this way, keeping them boiling for a long time, and allowing them to cool slowly. It was thought they resisted the changes of temperature to which they were exposed more thoroughly if so treated.

Another process, patented by Herr F. Siemens, is directed to the same end as that of M. de la Bastie. It consists in a method of heating and then pressing and suddenly cooling the glass to be hardened or tempered; but when the articles are such as are usually moulded, the hardening and tempering are accomplished at the same time as the pressing—*e.g.* the molten glass is run into suitable moulds and, while still highly heated, is squeezed, the moulds having the effect of giving the necessary cooling, without resorting to the liquid bath of M. Bastie. The material employed for the moulds depends on the nature and thickness of the glass: in cases where the cooling process must necessarily be a rapid one, metals of good conducting power, such as copper, are preferred; while in those where the cooling has to be effected more gradually, moulds of earthenware or other bad conductors of heat are employed. In cases where the glass articles to be operated upon vary in thickness, the conductivity of the parts of the moulds is varied accordingly, either by means of thicker metal near the thicker parts of the glass, or by making those parts of the mould of a better conducting material than the parts next the thinner portions of the glass. The moulds, too, must be kept at certain temperatures, varying according as the nature of the glass requires that they should be cooled to a greater or lesser degree. In ordinary practice, however, it is found that cast-iron moulds maintained at a temperature of boiling water or thereabouts, and earthenware moulds kept quite cool, yield very satisfactory results. The liquid glass may be conveyed direct into the moulds, or may be taken from the melting furnace on the blower's pipe, and shaped in the mould; but it is preferable to heat the articles after shaping or partial shaping before pressing and cooling them. This part of the process introduces the difficulty of keeping the articles in shape, and it is overcome by Herr Siemens by means of casings or shells of platinum, such shells being transferred to the mould with the glass to undergo the pressing and hardening process. The heating ovens may be of any suitable construction; but Herr Siemens prefers to employ regenerative gas muffle ovens, heated under the floors and over the crowns by the flames of gas and air, which pass from one set of regenerators to another, which latter becoming sufficiently heated, the currents are reversed in the well-known manner of alternated working. The muffle being completely closed in, the articles are protected from dust and other impurities, which in the open furnace are apt to settle on and damage the surface of the glass.

The lower halves of the moulds are mounted on trucks or hand carriages, and are run up to the furnace mouth or the oven as the case may be; and, having received the glass, are run under the respective upper halves, which may be loaded to give the desired pressure. The temperature of the moulds is kept at the required point by supplying them with liquid, and water at the boiling point is found to be well suited for the purpose. Herr Siemens claims the process described, of producing hard-pressed glass by treating it whilst heated in moulds at a lower temperature, whereby it is simultaneously compressed and hardened. He also claims the use of moulds having parts of varying thickness, or of different materials having various degrees of conductivity. A separate claim is also made for the use of the platinum moulds to maintain the articles in shape whilst being heated in the muffle.

There cannot be much doubt that the difficulties connected with these processes

will be overcome by careful attention to all the conditions involved, and that eventually the process of toughening glass will be one of considerable certainty.

ALEX. BAUER prepares hard or toughened glass by heating ordinary glass plates so strongly that they begin to bend from softening, and then dipping them into fused paraffin at 200°. The hot softened plates must not be cooled continuously and slowly, as is ordinarily done, but to a certain degree quickly, and then gradually. If the cooling be effected in this manner, it is impossible to cut the resulting glass with a diamond. With the hardness, the density also of the glass has increased from 2·429 to 2·438 of ordinary to 2·460 to 2·468 of the hard glass. BAUER says: 'It cannot be denied that the glass thus treated, though rendered more suitable for a variety of purposes to which it could not be previously applied, has become unsuitable for many other purposes. These glasses may be thrown repeatedly on the ground without fracture, but if they do break they fall into a multitude of small, sharply angular fragments, and if the edge be cut with a sharp file they are liable to fall to pieces with a slight blow at any time.'

MM. V. DE LUYNES and CH. FEIL have instituted some researches on the hardened glass, which they published in the *Comptes Rendus*, and which deserve attention.

On attempting to cut a piece of hardened glass either with the wheel, drill, or file, it almost invariably bursts like a RUPERT'S drop. A disc can, however, be drilled at its centre without fracturing; but it breaks if pierced at any other point, or if an attempt is made to saw it across any diameter. A square of hardened glass shows, when examined by polarised light, a black cross, the branches of which are parallel to the sides of the square; it is always possible to divide the plate according to these directions without breaking it, but any attempt to cut the glass beyond those lines, whether in a parallel or transverse direction, results in its fracture. The broken fragments are always arranged symmetrically with respect to the point at which the equilibrium was first disturbed.

When the two halves of a square of glass which has been thus divided are examined by polarised light, black bands and coloured fringes are noticed, the arrangement of which shows clearly that the molecular condition of the piece is not the same as was that of the plate before section. By placing the pieces directly above one another the fringes and black bands disappear, but by rotating either piece through 180 degrees the bands reappear, and then present the normal aspect of a plate whose thickness is equal to that of the whole arrangement. Hardened glass does not differ much in appearance from glass that has been annealed; but in the former the presence of air-bubbles, which often are of considerable size, is more frequently seen than in the latter. Very different opinions having been expressed concerning the origin of these bubbles, MM. DE LUYNES and FEIL were induced to study them.

Experience showed them that these bubbles are produced suddenly at the moment of hardening, and with glass apparently quite homogeneous. They seem to disappear again on annealing, but by means of a lens they can be seen as exceedingly small specks, occupying the same position as the original bubble. On rehardening the glass they expand to their original volume. A block of hardened glass was taken, containing several bubbles, the positions of which were marked; the glass was then annealed, in order that it might be cut, and the part containing bubbles was separated from that which contained none. The different fragments were then rehardened. The bubbles always reappeared where they had been originally noticed, but no bubbles were generated in those portions which were in the first instance free of them. It appeared, therefore, to be proved that the bubbles arose from the dilatation of very small quantities of gaseous matter existing in the original glass, and the process of hardening only developed them. These bubbles certainly appear to prove that the process of hardening produces a new molecular arrangement.

Experience has shown that the toughened glass is liable to sudden rupture under circumstances which have not been explained. The following communication was printed in the *Times* of October 12, 1876:—

'A singular instance of the behaviour of tempered glass comes to us from MRS. NASSAU SENIOR, who writes to say that on the 11th of last month she furnished 12 gas-burners with tempered glass globes purchased in London, and having the veritable label of M. DE LA BASTIE affixed to each. Two of these globes were fitted on burners in her bed-room, and on the night of the 6th instant, after the gas had been extinguished for exactly an hour, one of the globes burst with a report and fell in pieces on the floor, leaving the bottom ring still on the burner. These pieces, which were, of course, found to be perfectly cold, were some 2 or 3 inches long and 1 inch or so wide. Curiously enough, they continued for an hour or more splitting up and subdividing themselves into smaller and still smaller fragments, each split being accompanied by a slight report, until at length there was not a fragment larger than a hazel-nut, and the greater part of the glass was in pieces of about the size of a pea, and of a

crystalline form. In the morning it was found that the rim had fallen from the tumbler to the floor in atoms. It is interesting to note these facts, as they indicate that the tempering process affects glass in a most peculiar manner. It would appear desirable that an exhaustive physical investigation should be made in respect of this singular material.'

Another correspondent writes on October 14:—

'My experience of tempered glass is much the same as Mrs. Nassau Senior's. I purchased 6 tumblers made by a London manufacturer. Five of them are perfect, and are as clear and as well made as any glasses can be; but the sixth crumbled to pieces like small diamonds. At the time it broke there was only cold water in it.'

The liability of some glass wares to fracture has been made the subject of a careful study by M. Hagenbach, who states that the liability of some glass wares to fracture suddenly, without obvious cause, when exposed to small changes of temperature, and which depends on unusual degrees of expansion on the inside and outside of the objects, may be detected by examining them with polarised light, when they exhibit a more or less brilliant display of prismatic colour. In glass that has broken in this way the peculiarity is generally observable. On the other hand, the examination of a large collection of glass vessels of good temper, which had stood the test of long wear, proved that very few indeed displayed any traces of colour when viewed by polarised light.

GLASS EXPORTATION. The exportation of glass from Great Britain for the last three years has been—

Kind of Glass	Quantities			Value		
	1874	1875	1876	1874	1875	1876
Plate, rough or silvered, including looking-glasses or mirrors framed or not (sq. feet)	1,411,268	1,000,180	1,780,218	£218,005	£210,211	£197,434
Flint of all kinds . (cwt.)	101,743	104,676	90,874	[illegible]	314,280	263,400
Bottles, and manufactures of green or common glass (cwt.)	890,822	661,553	557,[illegible]	462,696	366,[illegible]	311,[illegible]
Other manufacture unenumerated . . . (cwt.)	121,600	114,324	92,873	200,707	173,[illegible]	142,019

GLASS, CHINESE. Several masses of glass of Chinese manufacture were examined by W. Kulmann, and from these the following results have been selected; 100 parts of the glass ware dried at 110° C. contained—

	1st Quality	2nd Quality
Silicic acid	78·09	74·19
Alumina	13·17	13·77
Ferric oxide	0·09	1·26
Manganese oxide . . .	traces	1·03
Lime	0·74	1·50
Magnesia	0·23	traces
Potash	2·00	3·01
Soda	2·32	2·84
Loss	2·60	2·66
	100·74	100·26

Dingl. *Polyt. Jour.* ccxx. p. 455.

GLASS, YELLOW, *its permeability to the Chemical Rays.*—There is generally a slight mistake in regard to yellow glass. There is no yellow glass coloured throughout the body with chloride of silver. The silver is never used except as a stain upon the surface only, and the glass is called lemon, yellow, orange, or red stained, according as a greater or less proportion of silver is used. We use carbon, iron, or some other colouring material when we wish to colour the whole body of the glass, and then it is called *pot metal.*

It is found that no yellow glass admits the yellow ray only. In any experiments with specimens which have been made in the clear skies of America, all the yellow glasses admit a sufficient amount of actinic influence to blacken the sensitive paper beneath them, and therefore photographers should be warned against their use, and recommend a double thickness of orange. Red, of course, is the most non-actinic, but it is too dazzling for the eyes.

The mistake about the actinic or non-actinic power of yellow glass (which is a very common one) may arise, or may have arisen in England, from the fact that a much longer time might elapse before the darkening of the sensitive paper beneath it than

in America, because of the sometimes cloudy and murky atmosphere which hangs over the city of London and other cities of England. At any rate, the following appears to be the order in which coloured glasses stand in stopping back the chemical rays:—

1. Red.
2. Orange. } Orange and green are about of equal power. Some green glasses
3. Green. } cast off a little more than some orange.
4. Yellow.
5. Violet.
6. Blue.

GLASS-SLAG.—Mr. Bashley Britten, of Red Hill, Surrey, has drawn attention to the *Utilisation of Blast Furnace Slag, with its Heat, for the Manufacture of Glass.* The chief points are stated as follows:—

'In order to produce the glass described by the author, the slag can be used in its heated state just as it leaves the blast furnace. He showed that 175 parts or tons of glass would be produced with the following economy. One hundred tons of it would cost an ironmaster nothing. Instead of the labour of mixing and handling in the usual way, the whole quantity of the material, only 75 tons, would have to be lifted into the furnace. The only ingredients to be bought are 65 tons of common yellow or red sand, to be had anywhere at a mere nominal price, and 10 tons of common sulphate of soda, which may be bought or made for about 20*s.* per ton. The necessary fuel would be limited to what is needed beyond the surplus heat of the slag to raise only three-sevenths of the glass to the required heat; and it is a question whether the greater part of even this might not be saved by bringing down some of the spare gases from the blast furnace and employing them with regenerators; if needed, they could easily be enriched with a little added carbon. Against these items there would be a set-off for the cost of removing the 100 tons of slag, which must otherwise be thrown away. Besides this, another and considerable saving would arise from the wear and tear of the glass furnace being lessened, in consequence of four-sevenths of the materials going into them being already fused. Under such circumstances, the total cost of the glass in a melted state ready for working is seen to be so extremely small that it is hardly safe to venture to express it in figures; it scarcely amounts to the value of the commonest bricks per ton. A cheaper glass than even this can be made by using a larger proportion of slag and less sand, thereby necessitating less fuel to effect combination. In fact, the slag from some ore is sufficiently silicious in itself to be converted into a black, or dark green, or amber glass. With the simple addition of soda and a little arsenic, which are taken up immediately, it becomes transparent and perfectly workable, and would be useful for many purposes, such as slabs, tiles, or other things for outdoor work; but it would not do for bottles or any utensils for holding powerful acids, as its want of silica renders it liable to be corroded. It need hardly be stated that glass of much superior quality to that indicated above may be produced. In regard to all other essentials, such as clearness, brilliancy, strength, plasticity in working, power of resisting acids, and the capability of being cut with the diamond, it may be made equal to any other. The practical question has to be considered of how far it is possible to combine the manufacture of glass and iron without in any way interfering with the necessary continuous operations of the blast furnace, for this, as a matter of course, is absolutely essential. Blast furnace works, where pig iron only is made, frequently stand in pairs in isolated situations, with plenty of space around, on which glass-works may be erected on any scale; and in many instances they might be built close up to the sides of the furnaces, and extending laterally away from the pig bed. In that case the slag might be run directly into the glass furnace, on the well-known plan of Mr. Siemens for continuous founding and working. Where there is insufficient room for this, the glass-works might be at some distance, and the slag could be collected and conveyed to them in a state of fusion in large covered iron ladles on wheels, similar to those used in some Bessemer steel-works, where the molten iron is carried upwards of a mile to be poured into the converters. These observations are founded on the results of a long series of experiments extending over the greater part of the last three years, in which the author has endeavoured to test, in every way open to him, the soundness of his conclusions before submitting them to criticism. The glass thus made can of course lay no claim to high quality in point of colour; still this is its only inferiority, and no doubt it may be improved in this respect.'

GLACIARIUM. In March 1876 a 'rink' was opened in Chelsea, the floor thereof being formed of real ice. Since that time the floating-bath on the river Thames has been placed in the hands of Mr. John Gamgee, and he formed there 3,000 square feet of solid and transparent ice.

The general principles of the glaciarium are as follows:—They consist of the circulation of a current of glycerine and water through a series of metal tubes immersed in

water, which is converted into ice and maintained in that condition. There are two ice machines with the necessary engines, one at each end of the bath. Each machine absorbs over 100,000 heat-units per hour, and it is stated that this immense effect is obtained by utilising about 6 horse-power per machine. The water of the Thames, at a temperature of about 40° or 42° Fahr., pumped freely through the condenser, maintains the pressure in the condenser at a minimum of one atmosphere and three-quarters, whereas the pressure in the refrigerator is only nominal, and corresponds to the temperature of about 0° Fahr. A rotatory pump drives about 4,000 gallons of glycerine and water per hour through each refrigerator, and this cold liquid traverses through the tubes of the glaciarium, and water outside them is thoroughly frozen. The special difficulties in maintaining congelation at the Charing Cross baths arise from the great radiation from the iron structure, which is caused by its immersion in the waters of the Thames, and by the extensive area of glass roof covering the whole, which greatly raises the temperature of the internal atmosphere, and is antagonistic to the development of artificial refrigeration. The desired result, however, has been attained, and ice 2 inches thick has been formed and skated upon. The machines act as twins. One supplies each alternate tube of 115 feet in length, and the glycerine, having passed through this, gravitates into the other machine, and, having been conducted through the refrigerator, passes back through the adjacent tube. In this way Mr. Gamgee secures what he terms his 'direct alternative' circulation, which is the special improvement in the Floating Glaciarium. Each machine is capable of controlling the entire circuit of pipes, so that, in the event of one failing, the other ensures the continuance of the process of congelation. It has been demonstrated, in fact, during the process of making the ice, that one machine is about sufficient to absorb the heat of radiation, which is exceptionally great in the floating structure. There is over a mile of wrought-iron flat tubing, which has been made under a very perfect system by the Metal Tube Company. The freezing-machines have been constructed by Messrs. Raoul Pictet and Company, the patentees of liquid sulphurous acid, with whom Mr. Gamgee is in co-operation.

It will be understood that the glycerine and water solution is kept at a low temperature by means of liquid sulphurous acid, which is constantly circulated between a refrigerator on one side and a condenser on the other, by means of an air-pump placed between the two, and driven by a steam engine. This result will be more clearly understood if we mention, that, as stated by Mr. Gamgee, for the maintenance of a rink having about 1,000 square yards of surface, with a vacuum machine, about 15 tons of coal per day will have to be used, while his present machines only require from 2 to 3 tons to do the same work. If such be the result in practice, it may fairly be anticipated that a considerable impetus will be given in the industrial arts to those processes and manufactures involving artificial refrigeration. Thus, for instance, in breweries, for every gallon of liquor cooled down by the machines at present in use, 6 or 8 gallons may probably be cooled by the novel expedients science has suggested. The physical change from the liquid to the gaseous condition is that which produces intense cold, as in the case of ether. But the reason why the apparatus is now worked more economically is that the expansion from the liquid to the gaseous state involves an increase in the volume of the present agent equal to only about one-tenth that of ether. A special feature with regard to the rink is the equable character of the circulation over the whole surface and the absolute abstraction of heat at all points. See Refrigerators.

GLONOINITE. A name given to one of the many preparations, similar to dynamite, which are made by causing some absorbent body to become saturated with nitro-glycerine. It is spoken of as being a very powerful explosive agent.

GLONOIN, OIL OF. A name occasionally given to nitro-glycerine.

GLUE, CHROMATED. If a solution of the bichromate of potash be mixed with glue or gelatine, it forms an excellent cementing material. The mixture is kept from the light till required for use, and the two surfaces of a fracture are coated with it, and then pressed or fastened together with a string. Placed in the sunshine, the bichromated glue soon becomes hard and insoluble, and after a few hours the broken object is found to be firmly cemented. If the work is done neatly the crack is scarcely to be seen, and even hot water will fail to dissolve the glue, which has been rendered insoluble by the light. Chrome glue may also be used to prepare waterproof articles, the material being stretched, coated two or three times with the solution, and exposed to light.

This is the result of peculiar conditions which were first observed by Mr. Mungo Ponton, who introduced the use of the bichromate of potash in photography. Mr. Robert Hunt a short time after published his process, which he called 'the chromotype,' which was the original of all the processes in which the peculiar action of chromic acid upon organic matter has been made available in the arts. See Photography.

GLYCERIN, CRYSTALLISED. Dr. Paul F. Van Hamel Roos read before the Chemical Society a paper on a peculiar solidification of glycerin, of which he has favoured us with the following account:—

'Two months ago I had the opportunity of observing in the chemical works of Messrs. Dunn and Company at Stratford, a quantity of 56 lb. of crystallised glycerin.

'The crystallisation seems to have been induced by the movement of the railway and by the cold of the first days of January of this year. The specific gravity of this glycerin was found by me at its melting-point, 60° Fahr., 1·261.

'The crystals are monoclinic, perfectly colourless, and of a pure sweet taste. By putting some of the crystals into ordinary good glycerin, magnificent crystals begin to develop, most of the impurities remaining in the mother liquor.

'When the crystals are melted at a very gentle heat, not exceeding 70°–80° Fahr., and afterwards exposed to a cold of 30° Fahr., a very small crystal of crystallised glycerin is sufficient to solidify all the liquid. When the liquid is kept for some time at 24° Fahr. the solidification is spontaneous, but moving the liquor vigorously seems to be indispensable to the solidification in the absence of a nucleus crystal.

'With regard to the fermentation of glycerin, it is mentioned by Professor Redtenbacher, about 20 years ago, that there are two different sorts of fermentation depending on the temperature. At 60° Fahr. the results of the fermentation were propionic acid, at 100° Fahr., alcohol, and butyric acid.

'As it was mentioned that the fermentation soon stops and leaves a certain amount of unchanged glycerin, it was very probable that this fermentation was due only to certain impurities which were contained in the glycerin on which Professor Redtenbacher experimented.

'To determine this, I took 36 grams of crystallised glycerin, 50 grams of distilled water, and 5 grams of washed German yeast, and mixed the whole well together. I also took the same quantities of *refined commercial glycerin* (sp. gr. 1·248), distilled water, and German yeast, and exposed both to a temperature of about 56°–60° Fahr.

'To determine whether the yeast was active or not, I mixed a few grams with an aqueous solution of sugar, and exposed this mixture at the same temperature.

'Since February 28 of this year (1876), both samples of glycerin failed to show the least trace of fermentation, but a few hours after the contact with yeast, the sugar showed a violent fermentation, as a proof that the yeast was quite active. These experiments are still going on, and as soon as I observe any alteration in either sample of glycerin, I hope to report it.

'As it is suggested that hydrocyanic acid is a test for the purity of glycerin, I compared the action of this acid on February 28 on two different samples of refined commercial glycerin (sp. gr. 1·248), and on melted crystallised glycerin, but up to the present time no alteration in colour or other visible change has taken place. I took for these experiments 2 ozs. of glycerin and about ½ oz. of hydrocyanic acid (5 per cent.).

'The solidification of the glycerin seems to depend especially upon its being perfectly pure and anhydrous.

'The least quantity of water or any other impurity hinders the crystallisation.

'The crystallisation does not seem to be induced by putting into refined commercial glycerin, crystals of other substances of the same system as crystallised glycerin, but my experiments in this direction are not yet finished. The crystallisability of the glycerin seems to be the best test for its highest purity, and at the same time a means of separating ordinary glycerin from almost all its impurities.'

GOLD. The production of gold in the globe from 1852 to 1875. Extracted from the *Journal Officiel de la République Française* for June 1876:—

1852	912	millions of francs
1853	773	"
1854	635	"
1855	675	"
1856	738	"
1857	666	"
1858	622	"
1859	623	"
1860	595	"
1861	557	"
1862	537	"
1863	523	"
1864	565	"
1865	600	"

1866	600 millions of francs
1867	580 " "
1868	600 " "
1869	605 " "
1870	580 " "
1871	550 " "
1872	573 " "
1873	518 " "
1874	452 " "
1875	468 " "
Total	14,618 millions of francs
	= £548,175,000 sterling.

The production of gold in the world in 1875 being, according to this return, of the value of 18,200,000*l.* sterling.

Gold in Africa.—For a very long period an idea has prevailed in Europe that parts of the interior of Africa contain gold, and it is not altogether improbable that this idea had its origin in facts which have now become too remote to trace. For since the traders in 'gold, frankincense, and myrrh,' down to the times of the tribes of Arab traders, previous to the discovery of the Cape of Good Hope and the occupation of its coast by the Portuguese, it is believed considerable quantities of gold were obtained from these parts. Indeed, so prevalent was the idea that the interior of Africa contained some 'El Dorado' at the time of the discovery of the Cape of Good Hope by the Portuguese, that it formed the principal inducement under which the Portuguese were led to occupy the east coast, from thence to make their explorations into the interior in search of the precious metal.

They soon hit upon 'sites' from which the natives had obtained gold in the country a little south of the Zambesi, but they found that, although gold existed, it only occurred in comparatively small quantities in the alluvial, and what occurred in quartz veins was not abundant enough to satisfy their expectations. They soon abandoned their settlement in the interior and, retired to the coast, which they have occupied till now, and constituted themselves at once a barrier to civilisation by securing a monopoly of all the native products in those parts. In more recent years travellers have penetrated into the interior from the much more distant coast of the British possessions in South Africa, and have found the auriferous districts which the Portuguese attempted to work for gold, but subsequently abandoned. These travellers state that the country bears evidence of being occupied at one time by a race much more civilised than the existing races, and that auriferous workings exist of much earlier date than those of the Portuguese. But these statements must be received with considerable caution, for the country is still very little known to Europeans, and it is not to be supposed that those who have visited it, chiefly missionaries or hunters, are all qualified to report on the mineral resources of it. This much, however, is certainly known. Gold exists. A company in this country is in possession of a concession from the chief of Matabele country for working for gold. Machinery has been forwarded for crushing and other working purposes, and has reached as far as Natal for transportation to the mines, when circumstances arose which forced the company to postpone their operations, the chief of which was the death of their principal agent, who had been foremost in obtaining the concession from the native authorities, and who was the only one who had obtained their confidence.

As, however, the country becomes more settled through the growth of civilisation and good government from the coast towards the interior, there remains strong reason to presume that these districts will produce gold in considerable quantities.

Further south, in the north-east part of the territory of the Transvaal Republic, gold has been discovered, and for the last four or five years has been worked without intermission, although at present the number of workers has been considerably reduced, principally on account of the unsettled state of the country, and of the unfortunate misunderstandings which exist between the Dutch 'boer' government and the natives, which at last culminated in open war. This auriferous district is situate about 100 miles north-east of Delagoa Bay, and this too will, no doubt, sooner or later, when the country is more settled, and communications opened with the coast through Delagoa Bay, instead of the only available but circuitous route by Natal, become productive of considerable quantities of the precious metal. For, although up to the present time the principal part of the gold which has been obtained from these tracts has been alluvial, still the country contains numerous quartz reefs impregnated with gold, one of which has already received the attention of an English company, who have erected some expensive machinery for crushing purposes. Abun-

dance of cheap labour exists in these tracts, and the climate is well adapted for Europeans. This auriferous region only requires the direction of European capital and enterprise to demonstrate its worth. But before it can receive the attention it deserves, it is necessary that the weak government of the Dutch Republic, and that too of the native chiefs, should be substituted by a government sufficiently strong to command the respect of both natives and Europeans, and one under which life and property will be considered secure. It is necessary, too, that some port on the east coast nearer than that of Natal should be made available for purposes of transport, Delagoa Bay being at present out of reach, on account of its being surrounded by a belt of country infested with a peculiar 'fly,' whose bite is considered fatal to bullocks; these being the only animals used for purposes of transport.

A railway line would obviate this difficulty, and is considered not at all impracticable. One has already been projected, and some kind of treaty been made between the Portuguese Government and that of the Transvaal with a view to its being carried out; but it is doubtful if the enterprise of the latter will be found equal to the undertaking.—S. O.

Since the above was written the Transvaal has passed under British rule, consequently important changes may be shortly looked for. A geological survey has been already commenced, and a mineral surveyor has been sent into the country.

Gold is mined for at Leydenburg and Eersteling, in the Transvaal Republic. The rocks in which it occurs are generally barren looking, and vary very much in stripe. The alluvial gold at Leydenburg has doubtless been supplied from two different sources. It is coarse and nuggetty as a rule, well rounded, and generally coated with oxide of iron. Lumps up to 10 lb. weight have been found; it is of good quality, worth from 75 to 80 fr. per ounce. The auriferous rocks at Eersteling are steatite and chloritic schist resting on gneiss, and overlaid by rocks which at Leydenburg are auriferous.—E. J. Dunn, *Further Notes on the Diamond Fields of South Africa*, Geological Society, June 1876.

GOLD ALLOYS. *Comportment of certain alloys under the action of the blow-pipe.*

Gold and tin (placed together on charcoal and subjected to the action of a reducing flame) unite quietly into a very brittle globule.

Gold and zinc do not combine *per se*. The zinc burns into oxide.

Gold and lead combine quietly, forming a grey brittle bead.

Gold and thallium unite quietly, but separate again to some extent during cooling. If the metals remain united, the button is dark blackish grey, and quite brittle.

Gold and bismuth unite quietly and readily, forming a very brittle globule.

Gold and copper and *gold and silver* unite and form a malleable globule. The last is '*Electrum*,' which see.—Professor E. J. Chapman, *Phil. Mag.*, December 1876.

GOLD AMALGAMATIONS. In connection with Pyrites (vol. iii. p. 673) some notices have been given respecting the best modes of treating sulphur ores for the precious metals. Mr. R. Brough Smyth, in his Progress Report on Victoria, gives the following notice, and appends Mr. Cosmo Newbery's notes on the 'amalgamation processes:'—

'In too many cases that have been brought before the Mining Department there has been a well-founded suspicion that lead and other base metals have been thrown into heaps of quartz prepared for the mill, with the intention of causing a loss of gold. It must be remembered, however, that in some of our quartz veins native silver, native copper, native antimony, and bismuth occur, and these may so reduce the value of the amalgam, or interfere with amalgamation, as to lead to the inference that there has been neglect or a fraudulent attempt to cause loss to the quartz-crusher.

'Native lead and native copper occur with gold in the washdirt of the deep *leads*, and rolled fragments of sulphide of antimony have been found also in the same deposits. Native zinc, too, it is said, has been discovered in the alluvium. These, undoubtedly, have been derived from veins of quartz, and as the sulphides of lead and copper, as well as the metals, are not rare in the veins, it is necessary to use caution in investigating the causes of the contamination of amalgams.

'Mr. Cosmo Newbery's notes are valuable and very interesting, and I give them here in his own words. He says:—

'"On several occasions I have had to examine gold and amalgam samples which, it was supposed, had been fraudulently contaminated with a base metal, with the view either of deceiving the gold buyer or of causing a loss of gold and mercury during the operations of crushing and amalgamation. In most of these instances the probability was that the alloys were accidentally produced, and that the sole cause of their formation was due to a want of knowledge as to the composition of the minerals associated with the gold in the quartz, and the results of the methods of treatment adopted upon these minerals.

'"The following notes may, therefore, be interesting to miners and quartz-crushers. Most of the facts stated are known to chemists and metallurgists. I can claim novelty for a few only. I have, however, verified all the statements by actual experiments with auriferous materials from our goldfields.

'"The base metals found on the occasions referred to above have been arsenic, antimony, bismuth, copper, iron, lead, and zinc.

'"*Arsenic.*—Native arsenic has not been found in the ores of the goldfields of Victoria, but this substance occurs largely in combination with iron and sulphur, in arsenical pyrites also, as arseniates of lead, copper, and iron. From any of these minerals it may be easily set free in the roasting furnaces and quartz kilns, especially the latter, owing to the fuel, and reducing gases produced by the imperfect combination, coming in contact with these ores. When the arsenic is thus set free, it passes through the furnace as vapour, and is readily taken up by the gold that may be present; for when gold is heated to redness, or any degree between that and its melting-point, it takes up arsenic, with which it forms a grey, easily fusible, brittle alloy; even when the arsenic is not in sufficient quantity to change the colour of the gold or its fusing point, it still renders it very brittle; one-thousandth part renders gold so brittle that it may be ground to a powder. Gold containing arsenic is more difficult to amalgamate than pure gold. If much arsenic is present, the amalgam is powdery and black, and floats on the surface of the mercury; the black colour is due to the separation of arsenic. This black powdery metallic arsenic does not unite at ordinary temperatures with mercury to form an amalgam, but it mixes with it, coating each globule with the black powder, thus preventing their uniting with each other, or, in other words, causing the mercury 'to flour.' Sodium amalgam aids the union of mercury floured by metallic arsenic; but if arsenious acid (common white arsenic) is present, it reduces it to the state of metallic arsenic.

'"Arsenical pyrites act seemingly in the same way as metallic arsenic with mercury; when ground with it, a large amount of black floured mercury is produced. If the pyrites is partly decomposed, this action is more energetic than with the original mineral. I could detect no actual combination with the mercury. The black coating was examined under the microscope, but only seemed to be a mixture of pyrites grains and globules of mercury, both very finely divided. When mercury covered thinly with this black coating is warmed, the coating is absorbed into the mass, and is liberated again as the mercury cools.

'"*Antimony.*—This metal occurs native at Maldon. In combination with sulphur (stibnite, grey antimony ore) and as oxide of antimony (Cervantite), it is found in many auriferous quartz veins, as rarer minerals such as white antimony (Valentinite), red antimony (kermesite), and in some of the more complex minerals such as tetrahedrite and Boulangerite.

'"From any of these the metal may be obtained during the process adopted for extracting gold from the ore. If antimonial ores are burnt in kilns or roasted in a furnace either for the purpose of rendering the quartz more friable or for getting rid of the antimony minerals, there is always a partial reduction unless the heat is very great and free access given to atmospheric air. This reduction of the ore producing metallic antimony is due to two causes—(1) the carbon of the fuel coming in contact with oxide of antimony, either native oxide or that produced in the furnace by the oxidation of the sulphide, reducing it and producing metal; or (2nd) by the action of the oxide on the sulphide, producing sulphurous acid and metallic antimony.

'"Metallic antimony has a great affinity for gold. It forms an alloy both when the two metals are melted together, or when the vapour of antimony is passed over heated gold. The alloy produced is grey in colour and very brittle, and amalgamates with mercury only after long contact and continual grinding or by heating the two together. The amalgam when formed floats on mercury and gradually gives up metallic antimony, as a fine powder when agitated with water. This antimonial powder carries off a quantity of mercury and gold amalgam entangled with it.

'"Sulphide of antimony is perhaps the worst mineral with which the quartz-crusher has to deal. It divides the mercury into a black 'flour' even more quickly than arsenical pyrites, and if this 'flour' is triturated with the intention of bringing the globules of mercury together, a chemical combination takes place. The mass gradually changes colour, passing from the original blue-black or dark-grey to a pure black and then through brown to a brown-red. Upon examination I found that the remaining mercury contained antimony, and that the brown-red non-metallic portion consisted of a mixture of undecomposed sulphide of antimony and sulphide of mercury.

'"Sodium amalgam was found to be worse than useless in bringing the globules of mercury, floured by sulphide of antimony, together. When only containing a small percentage of sodium it had no action, and when made stronger (sufficient sodium to cause only a slight evolution of hydrogen when the mercury was placed in water), it

decomposed, the sulphide of antimony forming sulphide of sodium, an amalgam of antimony and mercury and sulphuretted hydrogen. Sodium amalgam also reduces the metal from oxide of antimony.

"'If sulphide of antimony is fused with finely divided gold a portion of the gold enters into chemical combination with the ore, and is dissolved with the sulphide of antimony in alkaline solutions. Oxide of antimony has no effect on mercury or amalgam.

"'*Bismuth.*—This metal is much rarer than either of the two previously noted. The only occurrence of interest is at Maldon, where it is found as metallic bismuth, sulphide of bismuth, and an alloy of bismuth and gold. The sulphide of bismuth contained a large percentage of gold intimately mixed but not chemically combined with it.

"'Bismuth alloys readily with mercury, but does not seem to be so detrimental as arsenic or antimony. The sulphide causes the silver to separate into 'flour,' and gives rise to loss in the same way as other sulphides. The sulphide of bismuth from Maldon, though rich in gold, did not give it up to mercury when triburated with it. An assay by Mr. O. Rule gave 20 per cent. of gold.

"'*Copper.*—Native copper occurs in many of the quartz veins in the alluvial drifts, and in some of the rocks through which the quartz veins pass. Samples of this clayey rock from Egerton and Blackwood had the appearance of surface clays permeated with thin rootlets, the copper passing through them in all directions as thin threads. From such sources copper may be accidentally introduced into the crushing mill. Another constant source of copper is from the general wear and tear in the mine, &c.—copper tamping bars, tacks from the pump valves, and even the detonating cap used for firing blasting compounds. But from whatever source the metal is derived it is not injurious except so far as it reduces the standard of the gold with which it is alloyed. On the other hand, it may, by becoming amalgamated, aid in the collection of fine gold and divided mercury, acting in fact in the same way as copper plates.

"'*Iron.*—Under ordinary circumstances iron does not amalgamate with mercury, but as I find metallic iron in nearly all samples of dirty amalgam and mercury, and sometimes in samples of impure gold, I have included this metal in the list, and give the conditions under which it may be made to enter the amalgam.

"'Sodium amalgam readily wets the surface of iron and takes up small particles, becoming magnetic, though if a clean iron wire is immersed in sodium amalgam for several weeks it loses but little, if any, weight; so that it seems probable that the iron found in the amalgam when sodium has been used is simply held mechanically. Mercury containing about one per cent. of sodium will decompose salts of iron, giving what is termed iron amalgam; and perhaps in this way iron may be taken up, for when blanket sands and like materials, rich in pyrites, are placed in heaps prior to amalgamation, some of the pyrites undergoes decomposition, forming sulphate of iron, which would be decomposed in the amalgamating barrels, if an amalgam or mercury containing one per cent. of sodium were used; and there can be no doubt that the beneficial results to be obtained from sodium are completely lost by using it in too great quantity and thus causing the mercury to take up the base metals.

"'*Lead.*—This metal has a highly detrimental influence in the processes of amalgamation, and is often supposed to be used for fraudulent purposes, as a small quantity added to mercury will cause a loss of gold amalgam and mercury, through the lead amalgam rising to the surface of the mercury as a frothy scum, carrying with it any gold amalgam that may be present, and, by forming a coating over the mercury, preventing it taking up any gold that may pass over its surface. The lead amalgam, when thus brought to the surface, is easily broken up and carried away in a fine state of division by a stream of water passing over it. The whole of the lead amalgam does not rise to the surface at once, and cannot be completely removed from mercury by simple skimming, but the more the mercury holding it is agitated the quicker it rises. The only way to completely remove lead from mercury is by careful distillation.

"'There is but little doubt that in some instances lead has been used with the intention of causing a loss to the mine owners, but in the majority of cases it is accidentally derived from the ore. Recently metallic lead has been noted in what appears to be a sample from a quartz lode. The specimen was said to be obtained from a quartz lode at Maldon. With this exception I believe no metallic lead has been found in any of the quartz mines. In the alluvial mines it is often noted in small rounded masses, sometimes coated with carbonate of lead. The ores of lead, such as galena, antimonial lead, sulphate of lead, carbonate of lead, arseniate of lead, and phosphate of lead, are often met with, and from these the lead found in the amalgam or gold is in the majority of cases most probably obtained.

"'In the common kiln used for burning quartz, galena or the other ores may be easily reduced. In fact, if quartz containing these ores are burnt in a kiln, it is almost impossible to prevent the production of metallic lead. It is also a common practice to add wood or bark and chips to the charges of concentrated pyritous material, in the reverberatory furnaces, with the view probably of economising fuel. This will of course aid materially in reducing any metals like lead or antimony. Large quantities of lead (large when compared with the silver and gold) were produced from the St. Arnaud ore, treated by a dry crusher and then passed through a STETEFELDT furnace. In this instance the ores reduced were obtained from above the water-level of the mine, and the lead existed in them as arseniate and carbonate. The reduction was caused by the ore having to descend through a column of reducing gases, and could probably have been prevented by the introduction of a larger supply of heated air. It is to be noted that, though the yield was unsatisfactory and that a large percentage of lead was present in these trials at St. Arnaud, there was no complaint of loss of mercury, and a carefully conducted series of assays made of the pulverised ore, collected before it passed to the furnace, and samples of the tailings as they left the amalgamators, showed that the loss of gold and silver was not above the average. From these practical results it would seem that by carefully washing after amalgamating in pans (WHEELER'S were used, I believe), the great loss to be feared from the presence of lead in mercury, in Chilian mills and ripples of crushing batteries, may be so reduced as to be scarcely noticed.

"'*Zinc.*—There is but little possibility of this metal finding its way into the amalgamating machinery. Still it is possible that it may be found in gold being derived from the ores of zinc which occur in the quartz. I find that, if gold is exposed at a dull red heat to the vapour of zinc, a brittle alloy is formed, the zinc being taken up by the gold in the same manner as arsenic. The alloy is easily amalgamated by mercury.'"

GOLD ASSAY. Mr. W. CHANDLER ROBERTS reports to the meeting of the British Association at Bristol, 1875, that portions of the gold plate prepared with so much care had been sent to various distinguished chemists on the Continent and in America. Several reports have been received confirming the purity of the plate. M. STAS, of Brussels, gives the details of the experiments which he had made in testing the metal, the results proving that the plate contained 999·95 parts of pure gold in 1,000; the minute trace of foreign matter which is admixed with the gold being probably derived from the clay crucible in which the metal was melted. Spectrum analysis proves that neither silver, copper, nor iron exist in sufficient quantity to be detected by the spectroscope. With the completion of this standard plate an important step has been made, in that a standard for reference has been secured. With this standard completed, the committee now propose to collect evidence with regard to the discrepancies between different assayers, and they hope to be able to ascertain whether the cause of difference arises in the furnace or while parting with acid.

GOLD IN MINE WATERS. It has been suspected for many years—for how many years it would be difficult to say—that gold is contained in the waters of the ocean; and lately it has been proved by experiment that sea-water is auriferous and argentiferous—holding also many, if not all, other metals in solution.

SONSTADT has stated that 'the sea-water of the British coasts contains in solution, besides silver, an appreciable amount of gold, estimated by him at about one grain to a ton of water.'[1]

Now in our quartz veins there is constantly circulating saline waters—in some places waters of greater specific gravity than those of the ocean—and it has been often suggested that in these waters there are in solution salts of gold, and that the gold may be precipitated on coming into contact with metals or metallic sulphides. Nitric acid, which is always found in rain water, acts very slowly as a solvent of gold, but it does act upon it, and a certain amount of gold—how small it may be we cannot guess—must necessarily be carried with meteoric waters to great depths. In the presence of hydrochloric acid gold dissolves without the evolution of free chlorine.[2] A mixture of nitric and hydrochloric acids is well known as a solvent, and iodine in sea-water is the agent which, according to SONSTADT, keeps gold in a soluble and oxidised condition.

All the substances, organic and inorganic, which, acting and reacting on each other, would produce agents for holding gold in solution are present in sea water; and many of these substances are present also in the waters of our mines.

What condition the gold in the mine waters of our reefs is in we know not, but that gold exists in the mine waters is almost beyond doubt. Some time since Mr. NORMAN TAYLOR, when making a geological survey of the Stawell district, caused a small galvanic apparatus to be fixed in the pump tank of the NEWINGTON AND PLEASANT CREEK

[1] *Chemical and Geological Essays*, by THOMAS STERRY HUNT, LL.D., p. 237.
[2] *Reports of British Association.* E. J. FAIRLEY, F.R.G.S.

COMPANY's mine, for the purpose of ascertaining whether gold in solution exists in the very saline mine waters that are found circulating in the auriferous reefs intersected by the workings of the company. The apparatus was allowed to remain in the pump tank for a period of ten months, and was then sent to Mr. COSMO NEWBERY for examination. Mr. NEWBERY found that both the copper plate and the zinc plates were corroded and coated with an incrustation. The incrustation was carefully removed from the copper, and was found to contain sufficient gold to be detected by the blow-pipe assay process. A portion of the cleaned copper was then examined, and gold detected, and though apparently in less quantity than that found in the incrustation, it was sufficient to throw a doubt on the result. Upon close inspection the copper proved to be a portion of an old sheet or plate of copper, the holes in which had been stopped by rivets. To obtain satisfactory results it will be necessary to make the experiment with chemically pure copper, and to filter the mine water before it reaches the apparatus. Gold exists in a state of minute subdivision in all our mines—in particles, in fact, so minute that the utmost care will have to be used in filtering the water, and in protecting the apparatus from accidental contact with free gold.

Mr. COSMO NEWBERY was requested to undertake the control of the experiments which were made in some of the richer mines. Though the apparatus fixed by Mr. TAYLOR was not devised with such precautions as—partly in consequence of the experiment made by him—we should now use, the results therefrom are not without interest and value; and he is to be commended for making an attempt to ascertain the true character of our mine waters.

Some time since Mr. COSMO NEWBERY suggested that timber props, used for supports, which had been immersed for a long period in the waters of the mines, or buried underground, should be obtained, in order that they might be examined for gold; and at once Mr. BROUGH SMYTH placed himself in communication with some of the mining surveyors who are interested in scientific investigations, and asked them to collect specimens. They responded with commendable alacrity. Mr. THOMAS COWAN, Mining Surveyor at Ballarat; Mr. JOHN LYNCH, Mining Surveyor at Smythesdale; and Mr. NICHOLAS, Inspector of Mines at Sandhurst, collected and forwarded a number of pieces of wood. Mr. COWAN sent three pieces of timber, which had been buried in the earth for more than 14 years; Mr. LYNCH some which had been imbedded as long as 17 years; and Mr. NICHOLAS, props which had been immersed in mine water for 16 years.

All these were placed in the hands of Mr. COSMO NEWBERY for examination, and he reports as follows:—

'The majority of the samples of wood were too small for satisfactory examination, as it was found that at least 1 cubic ft. of wood was required for a satisfactory qualitative test; for a quantitative test several cubic feet should be used.

'In nearly all the samples the wood was undecomposed, but traversed in every direction by cracks, the whole of which could only be detected by thoroughly drying the wood. When opened, these cracks were found to be lined with a soft ferruginous clay, and this clay, in two instances, Nos. 1 and 12, was highly charged with iron pyrites in minute crystalline grains. I could not, unfortunately, collect sufficient of this pyrites to make a satisfactory test for gold.[1]

'A portion of the wood, separated from all earthy matter and cracks, was boiled in water, to which it gave up alkaline sulphates and chlorides. It was then thoroughly washed with hot water until it gave no further reaction for these salts, and then treated with nitrate of potash. The solution from this treatment again gave a strong reaction for sulphates, thus giving good evidence of the presence of sulphur compounds (pyrites) in the wood. Nos. 4, 5, 6, 7, 11, and 12 had grains of pyrites firmly attached on the outer portions.[2]

'Two quantities of wood, separated as carefully as possible from all cracks and external parts which might be contaminated with or contain accidental auriferous material, were burnt in a clean new muffle, and the ash collected; it was of a red colour, owing to the presence of a large quantity of oxide of iron. The bulk of the ash was reduced by washing with hot water and weak hydrochloric acid, and the residue fused with a weighed quantity of pure litharge and carbon; the resulting lead button was cupelled, leaving a notable amount of gold.

'Upon examining the ash obtained from the samples burnt, a silicious residue was

[1] No. 1. From the claims of SPARKHAKE and Co., from drives about 240 feet in depth—alluvial; No. 12. From a depth of 230 feet, and had remained underground for a period of about 13 years. BUTT claim, Scarsdale—alluvial.

[2] No. 4. From the Energetic mine, Sandhurst, under water for 16 years—quartz; No. 5. From KOCH's Pioneer Mine, Sandhurst, 16 years under water—quartz; No. 6. From Great Extended HUSTLER's mine, Sandhurst, 7 years under water—quartz; No. 7. From HUSTLER's Reef G. M. Co., Sandhurst, 4 years under water—quartz; No. 11. From Defiance mine, Scarsdale, depth 230 feet, buried 15 years—alluvial; No. 12. From Gemini mine, Scarsdale, depth 200 feet, buried 13 years—alluvial.

found, which, when examined by the microscope, showed rounded grains like quartz, so that it is possible, though scarcely probable, that the gold found may have been introduced into the wood with these quartz grains by force in the mine, such as blasts or heavy blows, or perhaps drawn into the wood during its first absorption of water after being placed in the mine.

'For these reasons it will be satisfactory to repeat the experiments, though I have no doubt that the gold exists in the wood, and that it has been precipitated there from a solution at the same time as the oxide of iron and the iron pyrites.'

Examinations will be made of timber from mines in other parts of the colony, and every care will be taken in procuring specimens and in conducting the experiments, so that it may be ascertained without doubt whether or not gold is precipitated from mine waters. The inquiry is one of the highest interest, and scientific men in all parts of the world will learn with satisfaction that this matter is being investigated with caution, and by an experienced chemist and metallurgist.

Under this head may be placed the results obtained by Mr. W. Skey on the gold of New Zealand:—1. After immersion for a few hours in spring water, or in water charged with any neutral salt, it was found that gold refused to amalgamate when subsequently immersed in mercury. 2. It is also brought into this condition when left in contact with distilled water for about 18 hours, or with an aqueous solution of caustic or carbonated alkali or ammonia at their boiling points, or for a longer time when the solution is used at the ordinary temperature. 3. Gold is also brought into this state when heated with a weak solution of carbonate of soda. 4. Weak acetic acid or hydrochloric acid on ignition readily converts the non-amalgamable surface into a readily-amalgamable one. 5. Gold becomes rapidly non-amalgamable in nitrate of silver or chloride of mercury; also in weak sulphuric acid, or when it is fused with borax and bisulphate of potassium.

It seems, therefore, tolerably certain that gold thus acted upon has been oxidised either to a sub-oxide or to the purple oxide of gold (?). Mr. W. Skey intends to investigate this subject further. (It appears that films of fluid are formed upon the surface of the gold, which prevents the immediate action of the mercury, and which may tend to promote the solution of gold in water.) 'Oxidation of Silver, Platinum, and Gold, and supposed Oxidation of Mercury by Oxygen in presence of Water,' *Transactions and Proceedings of the New Zealand Institute*, 1876.

Gold in America, North.—The production of gold in the States and Territories west of the Missouri River in 1876 was $44,000,000.

Gold in America, South.—A company has been formed at Santiago for working some gold streams in the Rio de los Minas, to the north of the colony of Punta Arenas, or Sandy Point, in the Straits of Magellan.

Gold in Caledonia, New.—The Rev. W. B. Clarke, in his anniversary address before the Royal Society of New South Wales for the year 1875, thus speaks of the gold field of New Caledonia:—

'It is in the mica-schist of the oldest (Cambrian) formations that gold was found about Poëbo in 1863; but in 1864, when Garnier passed that way, he found only one digger steadily at work, who afterwards abandoned it. Since then further trials have been made by English adventurers and others. . . . The description of the gold field may be worth giving. It is situated about 2 miles from Poëbo. The bed-rock is a garnetiferous mica-schist, which is covered by a red clay, resulting from the decomposition of ferriferous garnets. The rock sometimes takes a spheroidal form, and in the centre of the spheres the garnet is less abundant, and is replaced by a quartzose and pyritous matter, the masses themselves being extremely hard, and surrounded by the soft argillaceous products of decomposition. They are often covered with a bed of mammillated oxide of manganese. That the gold comes from the rock *in situ* was shown by the greater abundance of it in the sands nearest the rock in the dry bed of a river which traversed the deposit of clay.'

Gold in California. The Eureka Mine, Amoor County, furnishes some curious and interesting facts, in a measure subversive of certain recognised geological dogmas. It is commonly believed that the yield of gold must decrease in depth; but in this mine the value of the yield for the first 30 ft. was only 30*s.* to 60*s.* per ton, barely sufficient to pay expenses. Below that level it rose from 66*s.* to 84*s.*; at 100 ft. it yielded 5*l.* 12*s.*; at 200 ft., 7*l.* 4*s.*; and at 300 ft. it attained a yield of 12*l.* per ton. From this we may learn some important lessons. It shows that we must not apply scientific dogmas in all cases; that because the earth is poor, the mine must be unworthy of trial, or necessarily poor in depth. This mine yielded in one year a profit of 75,000*l.*, and has attained a depth of 1,200 ft. It is a noticeable feature that it exists at the junction of slate and greenstone, the latter being hard and compact, and forming the hanging wall, while the foot wall is composed of a soft argillaceous slate. To the junction of these two formations is ascribed much of the success of this

mine, and the continuity of the gold in depth, while the soft character of the foot-wall has enabled the mining to be conducted at little cost. The opinion that quartz veins grow poorer in descending appears to be unsupported by sufficient evidence; but there are a number of circumstances calculated to lead the superficial observer to that conclusion: one of these is found in the fact that as the portion of the reef exposed to atmospheric influence gets weathered, it is necessarily accompanied by the degradation of some of the quartz, in most cases leaving the gold; the capping is, therefore, not a fair sample of the quartz in the immediate vicinity: then, again, every reef varies in thickness in different portions of its length and depth, and a prospector would be most likely to select from the richest portions showing on the surface. Moreover, the gold almost invariably exists in branches, shoots, or chimneys, which cut the axis of the vein horizontally or vertically at all angles. Not unfrequently the gold will be on one or other of the walls for a certain distance, while all the rest of the reef is barren. Where several parallel reefs are found near each other, one may be rich in gold for a considerable distance while the other is barren; and when the gold suddenly dies out it will not unfrequently be found to commence in a parallel reef, but at a spot at right angles with the point at which it has ceased in the previously productive reefs. This phenomenon has been observed at Hawkin's Hill, in this colony. In the same way that a chimney or shoot of gold will be found to pass diagonally along a reef, leaving barren or poor ground above and below, it not unfrequently happens that other and sometimes richer shoots of gold are met with at greater depth, having a certain parallelism to the first shoot.[1]

In connection with the gold and silver mining of California, the Sutro tunnel is the most remarkable enterprise in mining being carried out in the state. It is to extend a distance of 3$\frac{7}{8}$ths miles, and drain the Comstock lodes to a depth of 2,000 ft., and will cost when completed one million sterling. The companies on this great lode have agreed to pay a certain sum on every ton of ore raised from the mines on completion of the work. On November 1, 1874, the tunnel had been driven 7,7[illegible]2 ft. During 3 weeks in October the tunnel was driven 90 to 93 ft. per week, the last week in October 116 ft. The size of the tunnel is 10 × 14, and in one month 360 ft. had been driven by the BURLEIGH drill, being the heaviest work of this kind on record. Comparing this work with some of our Australian mining, we will take, by way of example, the adit driven into the Belmore Mine, on the GREAT WESTERN COMPANY's property, near Sealy. The size of this adit is 6 × 4½, and in 18 months they have driven 480 ft. This gives 6·31 lineal, or 170 cubic ft. per week; while the Sutro tunnel, 116 × 10 × 14, gives 16,040 cubic ft., or nearly 10 times the work in a given time. In the Hoosac tunnel the average progress under the old system was 49 ft. per month. The work performed with the drills was at the rate of 150 ft. per month, at a greatly reduced cost, effecting a saving in time of over 5 years. Great as is the magnitude of the Sutro tunnel undertaking, there are several others eclipsing it in extent and cost. In the Hartz Mountains a tunnel was constructed 14 miles long, and in Saxony a tunnel of 15 miles is in course of construction, to drain the Freiberg mines. This has already taken several years, and will require 40 years more to complete.

The gold yield of California this year (1876) will probably be about $20,000,000, or as much as it was in 1875. Of this two-thirds may come from placer claims, and the remainder from quartz. The greater part of the placer gold is obtained by hydraulic action in the channels of dead rivers, with deposits of auriferous gravel several hundred feet deep, and a quarter or half a mile wide. Although many acres of deep gravel beds have been washed away to the bed-rock, large areas remain, and promise to yield a good profit for many years to come, though the product will doubtless decrease gradually. The placer mining camps which have no hydraulic washings are steadily declining. The gold quartz-mining industry of California is stationary in its general character. A large number of auriferous lodes, and even of mines partly opened, are neglected because the gross average yield per ton will not exceed $10, and that figure does not in most cases leave any profit; though in Australia, where labour costs half as much, and supplies are cheaper, many quartz mines are kept going for a gross yield of $5 per ton. The yield of the gold mines generally, unlike that of the silver mines, is not published regularly. Many gold mines are worked on a small scale, sometimes by two or three men. Few of them are incorporated in San Francisco; the stockholders are usually few, and live at the mine, they can get information by letter or orally; and, as the treasure is much more attractive to robbers than silver, the managers try to keep the amount of production and the times of shipment secret. In reference to a number of the most productive quartz mines of California it is impossible to get information for publication.—*The San Francisco Alta.*

[1] The existence of gold on one side of the reef has been noticed in Gippsland, Victoria, and elsewhere. In New Zealand it is very marked, at HEART'S Creek, Thames Gold Field.

Gold in China.—The district of Kirin is very rich in gold; and the Consul gives an account of the valley of Chia Ti Kou, some 30 miles long, in which there are rich diggings about five or six days' journey east by south from Kirin and Newchwang. The veins of quartz in the hill sides are very numerous. The quartz, when dug, is roasted, then crushed, and then washed on a cradle or 'slip,' and so rude and imperfect is the operation that it usually pays to wash the quartz two or three times. The quantity of gold found in a ton of quartz varies; but a Chinese miner, who showed the Consul a slab of quartz brought from these diggings, assured him that less than $250 worth of gold per ton is considered a poor yield. The miners in this locality are said to be a lawless set, and to have a very peculiar social organisation. It appears that a few years ago a formidable band of brigands infesting the Kirin province was put down by a levy of hunters and foresters under the leadership of a man named Han, and for this service the Government gave him an honorary button and permission to get gold in the mountain district lying to the east of Kirin. He pays an annual tribute of 20,000 taels, and governs absolutely within the limits of his concession, and no official writ runs there without his permission. He has an armed following, and a number of miners and workmen in his pay. Those who are not in his employ pay a royalty for permission to mine. The community under his rule are said to number about a thousand, and are principally Chinese, but a number of Coreans have recently found their way into the territory, and are working with considerable success. The Consul hears that little of the precious metal abides with the working digger, who is beset by the usual temptations to spend and squander. *Report of Mr.* Adkins, *British Consul at Newchwang.*

Gold at Clevedon, near Bristol, in Limestone.—A carboniferous limestone, containing gold and silver, has been discovered at Walton, in the neighbourhood of Clevedon, by Messrs. W. W. Stoddart and Pass. The analysis of the dried limestone gave—

Aluminium	·8777
Oxide of iron	4·8000
Carbonate of lime	94·3000
Silica	·0200
Silver	·0023
Gold	a trace
	100·0000

An assay was made by Mr. J. P. Merry, of Swansea; he found in one sample 94 grains to the ton, and another sample contained very nearly an ounce. The quantity of gold varied from 3 to 6 grains per ton.

Gold in Columbia, British.—The three recognised gold-fields of British Columbia are Cariboo, Omineca, and Cassiar.

The following table shows the yield of gold for the whole province, since its existence was first made known to the world in 1858, up to the present time. Two-thirds of the amounts here given were actually known to have been exported by the banks, &c., while one-third is added in each year as the amount estimated to have been carried away in private hands:—

1858, 6 months	$ 520,353	1868	$2,372,972
1859	1,615,072	1869	1,774,978
1860	2,228,543	1870	1,336,956
1861	2,666,118	1871	1,799,440
1862, 1863	4,246,266	1872	1,610,972
		1873	1,305,749
1864	3,735,850	1874	1,844,618
1865	3,491,205	1875	2,474,004
1866	2,662,106		
1867	2,480,868	18 years	$38,166,970

At the Philadelphia International Exhibition, 1876, examples of gold from sixteen creeks in the Cariboo district were exhibited. Specimens from several districts around Lake Superior were also shown.

Gold in India, Southern.—We have been favoured with some special information respecting the gold mines of Southern India.

The mining concession of the South of India Alpha Gold-Mining Company, Limited, embraces about three-quarters of a mile in length of the 'Alpha' (or

'Skull') Reef, extending from the edge of the Western Ghauts in the south to a distance of about one mile at the northern extremity from the village of Devallah.

The outcrop of the Alpha Reef may be followed over several mountain ridges for a distance of some miles in a northerly direction. The country rock is gneiss, foliated, more or less quartzose, and to some extent hornblendic. As appears to be common with auriferous reefs in South-East Wynaad, the richest portion of the lode is near the footwall, and the casing, which contains a large portion of iron rust (hydrous peroxide of iron), as well as numerous leaders of various thicknesses, seem likewise to have been found rich in gold.

Old workings, made by the Kurumbers in former times, can be traced all along the face of the mountains. Their primitive mode of working consisted in crushing the quartz between two stones, by hand, washing out the gold in a rough wooden dish, and then picking it up with mercury.

The average result of assays made of specimens selected from 'Skull' working was 22·68 dwts. per ton of stuff.

Another assay of 15 tons of mixed stone from the same workings gave 3 ozs. 0 dwt. 13 grs. per ton.

In the South-East Wynaad concessions have been taken up from the Rajah of Nellumboor, in the vicinity of Devála, which embraces an area of about 1,000 acres, within which 75 acres of quartz reefs might be selected for mining operations. Another grant is from the Madras Government over a block of 50 acres, some four miles distant from Cherumbody and Glenrock coffee estate. The following reefs have been examined:—

The Monarch Reef, the Bear Reef, the Corumber Reef, the Etacule Reef, and the Cavern Reef.

Gold appears to have been raised for centuries in this part of India. The old workers do not, however, appear to have penetrated to any considerable depth below the surface.

The attention of Government was called to the subject of the Malabar and Wynaad Gold-field in 1831, and a commission was appointed to report upon them. The report made was not of a favourable character.

The gold is frequently visible in the quartz, as well as the white iron pyrites, in which, and in the cubes, a large proportion of the precious metal is contained.

	Ozs.	dwts.	grs.	
The Monarch Reef, ordinary, gives by assay	0	11	16	per ton
Ditto. *the richest* " "	3	9	5	"
The Hamlin Reef gives by assay	1	0	5	"
The Bear Reef " "	1	11	0	"
The Corumber Reef " "	2	6	16	"
The Etacule Reef " "	0	15	13	"

Colar District, Mysore Territory, situated in the village of Ooregum, or rather about half a mile south of it. The reefs show the appearance of having been extensively worked from the surface by the natives; but in no instance has the ancient workings been carried to a depth exceeding 60 or 70 ft.

Gold is found all over the plateau, and in the nullahs, within the range of the quartz reefs, and the natives are even now in the habit of sweeping up the earth and dust, and washing them for gold, by which means they earn at the rate of from 3 to 4 annas a day.[1]

The assays made from twelve different samples, taken from the several reefs, give an average of 1 oz. 0 dwt. 18 grs. to the ton of stuff. From a pit worked by Colonel Beresford, some years since, specimens were obtained which were said to contain as much as 28 ozs. to the ton. Other assays of specimens, derived from other parts of the pit, gave 5 ozs., 6 ozs., and 10 ozs., to the ton of stuff.

Gold and Silver in Japan.—Although one hears much of the wealth of Japan in its gold and silver mines, there is little reliance to be placed in such statements, the total amount of these precious metals produced in the year 1874 being only 21,666 lb.; value 79,625*l*. There are silver mines in the island of Sado, in the possession of the Government, worked under the direction of foreign engineers, but they do not appear to be a very profitable investment, for their returns show that in one year, although 12,250*l*. worth of ore was extracted from the mines, the necessary working expenses amounted to 15,312*l*. There is also a gold mine under foreign superintendence at Oogana, in Ugo.

[1] 1 anna = 1½*d*. sterling.

The following list of the gold-fields of Yesso, Japan, is from the report by Mr. Henry S. Munroe, the Professor of Geology and Mining in the Imperial College of Tokio :—

Gold-field	District	Area in square yards	Average depth of Gravel in yards	Average value per cubic yard in cents
Toshibetsu	Upper Valley	960,000	3·30	5·60
	Remainder	5,114,000	3·30	3·00
Kudo	Moshibetsu	345,600	1·65	0·30
	Usubetsu	1,488,000	1·65	0·05
Esashi	Timikishi	493,000	1·98	0·20 to 1·00
	Otobe, &c.	not given	—	0·01 to 0·09
Matsumai	Matsumai	exhausted	—	—
Musa	Yunoshiri	1,200	2·00	0·61
	Remainder	3,851,400	2·64	0·70
Tokachi	Ayobeshuma	not given	7·00	0·03
	Sundry places	"	10· to 15·	nil.

The value of the gravel in most of these localities is so low that it will not pay for working.

Gold, New South Wales.

Table showing the Proportion of Gold and Silver in characteristic Samples of Gold Dust, from various localities in New South Wales, after melting. By F. B. Miller, F.C.S., *late Assayer in Sydney Branch of the Royal Mint* :—

Locality	Gold in 1,000 parts	Silver in 1,000 parts
Northern.		
Boonoo Boonoo	654 to 659	337 to 296
Fairfield	872	121
Timbarra	708 to 898	280 to 97
Peel River	929	67
Rocky River	934 to 962	61 to 33
Nundle	923 to 937	68 to 63
Western.		
Bathurst	827 to 903	164 to 92
Sofala	929 to 933	66 to 63
Tuena	943	54
Ophir	915	82
Tambaroora	943 to 954	54 to 42
Turon	918 to 928	76 to 68
Hargraves	915	83
Windeyer	946 to 950	53 to 47
Southern.		
Burrangong	948	45
Adelong	946 to 951	52 to 45
Braidwood	928 to 934	67 to 62
Emu Creek	971	27
Delegate	971	27
Nerrigundah	983	15

The following list cannot fail to be of interest as showing the peculiar characteristics of the gold of New South Wales. It is from the *New South Wales Official Catalogue, Philadelphia Exhibition*, 1876 :—

Samples of Gold characteristic of the Gold-fields of New South Wales exhibited by the Mining Department, and assayed at the Royal Mint, Sydney.

Locality	Description of Gold, each sample weighing 2 ozs.	Loss in melting per cent.	Gold and Silver in 1,000 parts after melting		Value per oz., after melting, at 3l. 17s. 10½d. standard
			Gold	Silver	£ s. d.
WESTERN DISTRICT.					
Sofala	In fine scales, and coarse plates and grs.	1·64	923·0	72	3 18 9½
Bathurst	Fine scales and coarse grains, with some spongy and stringy	2·00	929·5	71	3 18 10
	Fine scales, plates, and coarse grains	1·47	918·0	70	3 18 4½
Hargraves	Fine dust and coarse grains	1·23	920·5	70	3 18 9¾
	Scaly with some grains	1·10	941·0	59	4 1 0¾
Tambaroora	Fine and coarse scaly and grains	1·81	940·0	54	4 0 1
	Fine scales and grains	1·66	942·5	50	4 0 8
	Rod gold; reticulated	2·77	944·0	51	4 0 8
	Coarse waterworn grains or nuggets	2·00	925·5	64	3 18 8½
Hill End	Fine dust and coarse grains	2·47	944·5	47	4 0 7
	Scaly, with coarse spongy grains	1·41	945·0	50	4 0 7
	Fine scales and coarse crystalline gold	2·18	947·0	47	4 0 8½
	Scaly and coarse filiform gold	1·07	942·5	40	4 0 4
Mudgee	Fine scales and coarse grains	1·99	941·0	56	4 0 5½
	Coarse grains with some scales	3·04	926·0	68	3 18 0
	Fine and coarse scales	1·77	937·0	58	3 18 10½
	Coarse spongy grains and some scales	1·78	935·0	58	3 18 11½
Gulong	Dust and coarse scales	1·78	919·5	75	3 18 3
	Coarse pieces—filiform and spongy	1·78	925·0	70	3 18 11
	Scaly, with some grains	1·68	946·0	48	4 0 7½
Carcoar	Fine scales, very porous, with some magnetic iron	10·05	876·0	119	3 16 2
	Fine and coarse filiform gold of a dark colour	2·04	960·0	36	4 1 7½
Orange	Scaly	2·07	943·0	51	4 0 4½
	Fine dust—'gunpowder gold'	2·63	900·5	62	3 15 4
Stony Creek	Scaly	1·56	942·0	54	4 0 3½
SOUTHERN DISTRICT.					
Braidwood	Plates and fine scaly	1·79	960·0	34	4 1 7½
Araluen	Fine dust—'gunpowder gold'	2·13	951·5	42	4 1 0¾
Adelong	Fine scaly and coarse filiform	2·62	944·0	52	4 0 5½
	Scaly	1·27	941·0	53	4 0 3
	Coarse filiform with some scaly	1·69	940·0	50	4 0 7½
Tumut	Fine and coarse, with some very spongy	5·76	927·5	70	3 19 1½
Young	Scaly dust gold	2·39	937·0	60	4 1 7¾
	Fine dust—'gunpowder gold'	1·54	943·0	49	4 0 9½
Nerrigundah	Strings, scales, and plates	1·64	950·5	13	4 3 4¾
Kiandra	Scales and plates, with some grains and threads	8·16	927·0	63	3 19 1
Goulburn	Coarse grains and reticulated	0·67	975·0	22	4 3 11½
Bombala	Very fine scaly dust—'gunpowder gold'	2·63	953·0	34	4 1 11½
Cooma	Filiform crystalline and some scaly	0·17	938·0	58	3 19 11½
		4·22	924·0	70	3 18 10
NORTHERN DISTRICT.					
Nundle	Fine scaly and coarse filiform	0·22	910·5	73	3 18 0
	Scales, plates, and coarse filiform; of a brownish colour	3·24	908·1	90	3 17 1¾
Tamworth	Spongy, filiform, and crystalline, some with a little quartz attached	0·29	912·0	83	3 17 10½
		3·61	914·0	80	3 18 1¾
	Fine dust and shotty grains	3·31	900·5	92	3 18 10½
Armidale	Scales with some threads	3·20	948·0	44	4 4 0
	Fine scales	1·91	899·5	105	3 16 0

The average fineness of Victorian gold is about 23 carats, that is to say, it contains about 96 per cent. gold and 3½ per cent. of silver, with about ½ per cent. of other metals. Further north, in New South Wales, the average fineness is 22 carats 1½ grains, or 93½ per cent. gold and 6 per cent. silver. Still further north, in Queensland, the average fineness is but little more than 21 carats, or 87·25 per cent. gold, and 12 per cent. silver. Maryborough gold only contains 85 per cent. gold and as much as 14 per cent. silver. (F. B. MILLER, F.C.S., *Trans. Roy. Soc., N.S.W.*, 1870.)

The Palmer gold, from Northern Queensland, is much richer than any of the specimens from Queensland referred to above.

Amount.—The total quantity of gold, as recorded in the Government returns from 1851 to 1874, was 8,205,232,598 ozs., and the value 30,536,246*l.* 10*s.* 6*d.*

Years	Received at Mint	Exported without passing through Mint	Total quantity	Value of Gold received at Mint	Value of Gold exported	Total Value
	Ozs.	Ozs.	Ozs.	£ s. d.	£ s. d.	£ s. d.
1872	331,372·19	93,820·72	425,190·91	1,276,127 4 11	364,454 12 0	1,640,581 16 11
1873	259,570·77	102,214·94	361,784·71	997,214 19 11	397,960 9 8	1,395,175 8 7
1874	263,316·30	37,006·72	300,322·31	898,147 10 2	142,181 3 3	1,040,328 13 5

The Mining Registrar's returns of gold in 1875 and 1876 were:—

1875 . . 218,109 ozs. 1876 . . 167,411 ozs.
Decrease in the yield of 1876 . . . . . 50,698 „

Escort Returns of Gold.

Name of Gold-field	1872	1873	1874
Western District.			
	Ozs.	Ozs.	Ozs.
Sofala	10,765·16	9,507·90	9,372·65
Bathurst	9,505·62	9,738·70	10,470·90
Hargraves	4,102·40	4,445·85	3,603·40
Tambaroora	80,592·46	62,854·48	25,266·18
Mudgee	140,558·81	131,124·77	75,884·74
Orange	7,670·01	5,396·98	7,170·94
Stony	4,405·70	5,285·11	2,457·37
Forbes	—	628·92	532·67
Weddin	—	—	—
Grenfell	36,413·55	32,720·82	5,011·07
Carcoar	12,984·04	6,224·34	7,489·97
Southern District.			
Goulburn	1,327·10	364·28	309·10
Braidwood	15,644·61	10,036·88	10,320·85
Tumut	4,282·26	2,654·81	2,331·96
Gundagai	874·50	1,309·50	2,331·61
Moruya	—	—	—
Tumberumba	3,719·87	825·63	217·32
Adelong	17,042·41	21,607·78	17,850·60
Kiandra	648·10	—	—
Cooma	2,293·19	2,091·80	1,421·62
Yass	—	—	48·01
Burrangong	8,475·48	3,815·42	3,496·40
Nerrigundah	—	—	—
Araluen	20,009·59	7,230·53	4,554·41
Northern District.			
Rocky River	1,569·66	2,242·18	2,155·85
Nundle	4,309·53	3,862·43	3,557·86
Tamworth	1,497·64	1,160·82	1,057·72
Timbarra	—	—	—
Grafton	—	—	—
Scone	63·59	45·70	—
Armidale	2,575·94	1,766·07	1,708·71
Total . .	392,180·06	328,107·93	213,518·13

GOLD IN VICTORIA.—The estimates of gold raised in Victoria during the years 1872, 1873, 1874, and 1875, are as follows:—

	1872			1873			1874			1875		
	Ozs.	dwts.	grs.	Ozs.	dwts.	grs.	Ozs.	dwts.	grs.	Ozs.	dwts.	grs.
Exported, according to the returns furnished by the Hon. the Commissioner of Trade and Customs	1,380,684	19	0	1,310,267	14	0	984,154	0	0	709,924	18	0
Received at the Melbourne branch of the Royal Mint	151,868	17	0	164,801	0	0	351,817	19	0	363,842	3	0
Raised according to estimate made by the Mining Registrars	1,331,377	18	0	1,170,397	13	0	1,097,644	0	0	1,068,418	0	0
Purchased, from returns made by the managers of banks and others	1,249,094	8	0	1,165,492	14	0	1,100,115	0	0	1,077,378	4	4

As compared with the estimated yields given for the year 1872, there is a falling off in 1873 in the quantity of gold exported and received into the Mint equal to 61,641 ozs. 16 dwts.; for 1874, as compared with 1873, 64,907 ozs. 1 dwt., and for 1876, as compared with 1874, 60,164 ozs. 18 dwts.

The results of the returns of gold obtained from alluvial and quartz mining respectively in each year are given below:—

	Alluvial	Quartz
In 1868 the estimate was	1,087,602 ozs.	597,416 ozs.
" 1869 " "	934,082 "	610,674 "
" 1870 " "	718,729 "	585,575 "
" 1871 " "	698,190 "	670,752 "
" 1872 " "	639,551 "	691,826 "
" 1873 " "	504,250 "	666,147 "
" 1874 " "	433,283 "	664,360 "
" 1875 " "	426,611 "	641,806 "
" 1876 " "	357,012 "	698,005 "

The quantity of gold, the produce of Victoria, received at the Melbourne branch of the Royal Mint during each quarter of 1876:—

1876	Gross Weight of Rough Gold	Gross Weight of Gold Bullion
	Ozs.	Ozs.
The quarter ending March 31 . . .	4,332·68	77,654·98
" " June 30 . . .	6,740·83	112,077·35
" " September 30 . .	5,008·40	100,388·03
" " December 31 . . .	6,766·98	112,700·62

From information obtained from gold buyers and others by the mining surveyors and mining registrars, the total quantities of gold got respectively from alluvium and quartz reefs were as follows:—

1876	Alluvial		Quartz		Total	
	Ozs.	dwts.	Ozs.	dwts.	Ozs.	dwts.
Quarter ending March 31 . . .	97,985	10	142,044	3	240,029	13
" " June 30 . . .	93,924	12	146,357	2	240,281	14
" " September 30 . .	86,716	6	158,192	12	244,908	10
" " December 31 . . .	79,274	17	149·365	8	228,640	5

The following table, compiled for the *Argus* newspaper, gives the average number of miners employed and the quantity of gold produced during the last eleven years:—

Year	No. of Miners	Yield of Gold	Year	No. of Miners	Yield of Gold
		Ozs.			Ozs.
1866	73,749	1,536,681	1872	54,651	1,317,102
1867	66,957	1,493,831	1873	52,544	1,249,407
1868	63,181	1,474,187	1874	46,800	1,102,614
1869	68,037	1,367,903	1875	42,000	1,068,823
1870	60,367	1,281,841	1876	41,564	937,260
1871	58,101	1,303,379			

The Mining Department compile returns, as given above, of the yield of gold in each year, but their conclusions are based on estimates formed by their mining registrars on the various gold-fields, and cannot be considered as more than estimates, whereas the returns to the *Argus* are said to be almost correct. See Pyrites, Auriferous.

List of Gold Nuggets found in Victoria from October 1, 1874, to September 30, 1875; showing the Localities where found, the Date of Discovery, the Name of Discoverer, and the Depth at which each Nugget was obtained :—

Locality, and by whom found	Date of Discovery	Gross Weight (Troy)	Depth at which found
		Lb. oz. dwt. gr.	Ft. in.
[1] Found at Golden Point, Fryerstown, by John Rabner. Information received at Office of Mines on September 23, 1875 .	April, 1852	4 0 0 0	Surface
[1] Found at Fryer's Creek, by George Williams. Information received at Office of Mines on September 7, 1875 . .	1854	1 4 0 0	Near surface
[1] Found at Fryer's Creek, by George Williams. Information received at Office of Mines on September 7, 1875 . .	1854	1 0 10 0	16 0
[1] Found at Fryer's Creek, by George Williams. Information received at Office of Mines on September 7, 1875 . .	1854	2 6 0 0	16 0
[1] Found at Fryer's Creek, by the Ballarat Gold-Mining Company. Information received at Office of Mines on September 7, 1875	1859	5 5 17 0	14 to 16 ft.
[1] Found at Maximilian Creek, a tributary of Freestone Creek, Donnelly's Creek Division, by James Dunn. Information received at Office of Mines on January 4, 1875 . . .	Sept. 3, 1874	1 5 3 0	2 0
[1] Found at Maximilian Creek, a tributary of Freestone Creek, Donnelly's Creek Division, by James Dunn. Information received at Office of Mines on January 4, 1875 . . .	Sept. 3, 1874	0 1 5 0	2 0
Found near the Butler's Reef Company's ground, Heathcote, by E. Hansen. Information received at Office of Mines on November 20, 1874 . . .	Not stated	10 0 0 0	1 6

[1] The information respecting these nuggets was received at the Office of Mines during the year 1875.

Locality, and by whom found	Date of Discovery	Gross Weight (Troy)				Depth at which found	
		Lb.	oz.	dwt.	gr.	Ft.	In.
Found at Maximilian Creek, Upper Gladstone, Donnelly's Creek Division, by R. M. Thomson	Dec. 4, 1874	0	5	3	12	7	0
Found at Cobblers' Gully, Caledonia, St. Andrew's Division, by James Goodson (3 nuggets) .	Dec. 24 and 28, 1874	0 2 8	6 4 7	6 11 10	0 0 0	6	0
Found at Specimen Gully, near Jones's Creek, Dunolly Division, by Joseph Tyson Bragg and Edward Robinson . . .	Jan. 7, 1875	6	10	0	0	14	0
Found at Sebastopol, near Middleton Creek, Fryer's Creek Division, by Thos. Jones, senior .	Feb. 5, 1875	2	6	5	0	5	0
Found at Springhill, Creswick Division, by the Western Lewers Freehold Gold-Mining Company . . .	March 6, 1875	4	5	0	0	190	0
Found in the neighbourhood of Amherst, by Robert McWhirter	March 12, 1875	1	2	0	0	6	0
Found at Specimen Gully, Jones's Creek, Dunolly Division, by Joseph Tyson Bragg and Edward Robinson . . .	March 25, 1875	3	0	0	0	14	6
Found at Springhill, Creswick Division, by Richardson's Western Freehold Gold-Mining Company . . .	April 2, 1875	9	4	0	0	196	0
Found at Upper Sheepwash, Sandhurst Division, by Denny .	April 23, 1875	1	3	17	12	Surface	
Found at Hard Hills, Berlin, Inglewood Division, by Thomas Worden and Robert Baird .	May 12, 1875	6	0	0	0	33	0
Found at a blind gully near Ironstone Hill, Sandhurst Division .	About June 18, 1875	5	0	0	0	1	6
Found at Springhill, Creswick Division, by Richardson's Western Freehold Gold-Mining Company . . .	June 21, 1875	3	9	0	0	196	0
Found at Blacksmith's Gully, Amherst Division, by James Brogan	July 1, 1875	5	3	5	0	0	6
Found in the Amherst Division (name and locality refused) .	July 9, 1875	2	1	5	0	Not stated	
Found at Clunes by the Lothair Company	July 11, 1875	8	11	4	0	307	0
Found at Cruse's Gully, Sandhurst Division, by Marks and McKenzie	July 13, 1875	3	10	15	0	3	0
Found at Buninyong, in the Board of Advice Company's co-operative alluvial claim	July 21, 1875	4	11	10	0	73	0
Found at Yorkshire Flat, Wedderburn Division, by Robert Edmonds and Thomas Elliot .	Aug. 12, 1875	0 0 0	11 1 1	4 7 3	0 0 0	9 Not stated "	0
Found at Old Tom Gully, Hepburn Division, by a sluicing party	Aug. 25, 1875	1	11	6	0	5	0
Found at Whiskey Lead, Hepburn Division, by Toomey and Jackson	Sept. 3, 1875	10	10	0	0	14	0

Locality, and by whom found	Date of Discovery	Gross Weigh (Troy)	Depth at which found
		Lb. oz. dwt. gr.	Ft. in.
Found at TARA'S HALL GOLD-MINING COMPANY'S claim, Amherst Division, by RICHARD ALLNUTT	Sept. 9, 1875	0 10 4 0	50 0
Found at Blackwood, by ROBERT SPINNER and his son . .	Sept. 17, 1875	1 8 12 0	6 6

GOLD, NEW ZEALAND, OTAGO. In relation to the grouping of the gold reefs, Dr. G. H. F. ULRICH writes :—

'The auriferous reefs opened throughout the province differ very much both in structure and mode of development; still there are some districts of which, though they lie rather far apart, the reefs show much resemblance to each other; whilst in other districts comparatively close together, the difference in the nature and behaviour of the reefs is very great indeed. The reefs and other occurrences of gold in matrix may be grouped as follows :—

1st *group*. The Saddle Hill Reef, Green Island, near Dunedin; the Reefs of Tokomairiro (Canada Reef, &c.); the Gabril Gully Reef, near Lawrence; the O. P. Q. Reef, Waipori.—2*nd group*. The Reefs of Bendigo, near Cromwell; the Rough Ridge Reefs; the CONROY'S Gully Reef, near Alexandra.—3*rd group*. The Reefs of Carrick Range.—4*th group*. The Reefs of ARROW and SKIPPER'S Creek.—5*th group*. The Reefs of MACRAE'S Flat and Shay Valley.—6*th group*. Exceptional occurrences of gold in matrix; the so-called Peninsula Quartz Reef at Portobello.

In the newer drifts Dr. ULRICH mentions extensive sluicing operations along the banks of the Molyneux, Kawarau, and Shotover rivers. Hydraulic sluicing was being carried on on a grand scale at Trickers and Blue Duck Chain. At the Dry Bread diggings 40 sluice leads of water, with a mean vertical pressure of 130 ft., lessened by about 25 ft. through friction in the pipes, were employed, and these were connected with 4,500 ft. of iron piping. The older drift comprehends all the enormous deposits of harder gravel and cement called 'false bottom,' upon which the newer drift rests, in the extensive old lake basins of the Mamaherikia, Upper Taieri, Clutha, and other river valleys.

GOLD IN NOVA SCOTIA. Gold was first discovered in Nova Scotia in 1859. Since that time the average annual yield for the province has been over 17,000 ozs., the quantity for the fourteen years from 1862 to 1875, both inclusive, having been 242,072 ozs. 14 dwts. 22 grs., according to the Mines Department. This was obtained from 325,363 tons of quartz, which would give an average yield of 14 dwts. 21 grs. per ton. But counting at the official estimate of $18 per ounce, and reckoning 300 working days to the year, the above amount would give an average of $525 a year for each man engaged in the industry. There has, however, been an almost steady increase from $249 per man, in 1862, to $660 in 1875. Twelve steam and eight water-power stamp mills were in operation more or less regularly during the year, but most of these mills are of small capacity, the quartz crushed having amounted to only 14,810 tons for the twelve months.

The gold-bearing rocks form a broad belt along nearly the whole Atlantic coast of Nova Scotia proper. They consist usually of compact, white-weathering, greenish-grey felsitic quartzite, sometimes approaching in character to sandstone, interstratified with beds of slate, generally of a similar colour to the quartzite; but frequently the slaty bands are dark grey or nearly black. Several areas of coarse, reddish-grey granite of considerable extent occur within the gold-bearing belt of rocks. The gold is found in separate limited districts, of which about twenty are known. It generally occurs in thin interlaminated veins of hyaline quartz, accompanying the slaty bands. The outcrops of the veins, in each district, appear to be arranged in concentric lines, approaching the form of ellipses, due to domes along anticlinal axes.

GOLD IN PYRITES. See PYRITES, AURIFEROUS.

GOLD IN STRATA, CARBONIFEROUS. The Rev. W. B. CLARKE is said to have discovered gold in the coal measures in the southern districts of Sydney. Gold is also stated to occur in the coal measures at Peak Down in Queensland, near Hobart Town in Tasmania, and in New Zealand. Mr. C. S. WILKINSON, one of the Geological Survey of New South Wales, states in the annual report for 1876 that north of Gulgong, at Tallawang, the coal-measures cover a large extent of country, and their lower beds have been found to be payably auriferous. This is the first

time that gold has been noticed in payable quantity in the coal measures of New South Wales.

Apart from the scientific interest attaching to the subject of the geological age of auriferous alluvia, the fact that gold in payable quantity has been proved to exist in the coal measures is one of considerable importance, for it may lead not only to the working of some of the conglomerate beds at the Old Tallawang Diggings, but also to the discovery of other similar auriferous patches which no doubt occur in the Tallawang gold-field and in other parts of the colony where the same geological features are presented.

GOLD-PRODUCT OF THE UNITED STATES. The following table, constructed by Dr. Rossiter W. Raymond, is offered as an approximate estimate of the gold product of the United States since 1847, and is the result of careful study of numerous treatises and partial statistics, in the light of much personal observation of the principal producing districts. Down to 1862, it follows the table compiled by J. Arthur Phillips, and published in his *Gold and Silver*. From 1862 to 1866, the production of California is calculated by deducting from the express receipts of uncoined treasure at San Francisco, from 'the northern and southern mines,' the receipts from Nevada, and adding 10 per cent. to the remainder, to cover amount shipped in private hands. From 1866 to 1872 inclusive, the reports of the United States Mining Commissioner have been followed as a general authority; but as these do not separate the product of gold from that of silver, the division has been made by estimate, based on the known conditions and relations of the industry of different localities. The figures for 1873 are based on the express shipments, with arbitrary allowances for product otherwise transported. Under the head of 'Other States and Territories,' is included the product of gold from Oregon, Washington, Idaho, Montana, Colorado, &c., and one-third of the product of the Comstock lode in Nevada, that being the average proportion of gold by value in the Comstock bullion. The values are given in United States gold coin:—

Estimate of Gold Product of the United States from 1848 *to* 1873.

Years	California	Other States and Territories	Total
1848	$10,000,000	—	$10,000,000
1849	40,000,000	—	40,000,000
1850	50,000,000	—	50,000,000
1851	55,000,000	—	55,000,000
1852	60,000,000	—	60,000,000
1853	65,000,000	—	65,000,000
1854	60,000,000	—	60,000,000
1855	55,000,000	—	55,000,000
1856	55,000,000	—	55,000,000
1857	55,000,000	—	55,000,000
1858	50,000,000	—	50,000,000
1859	50,000,000	—	50,000,000
1860	45,000,000	$1,000,000	46,000,000
1861	40,000,000	3,000,000	43,000,000
1862	34,700,000	4,500,000	39,200,000
1863	30,000,000	10,000,000	40,000,000
1864	26,600,000	19,500,000	46,100,000
1865	28,500,000	24,725,000	53,225,000
1866	25,500,000	28,000,000	53,500,000
1867	25,000,000	26,725,000	51,725,000
1868	22,000,000	26,000,000	48,000,000
1869	22,500,000	27,000,000	49,500,000
1870	25,000,000	25,000,000	50,000,000
1871	20,000,000	23,500,000	43,500,000
1872	19,000,000	17,000,000	36,000,000
1873	17,000,000	19,000,000	36,000,000
Total	$985,800,000	$254,950,000	$1,240,750,000

Transactions of the American Institute of Mining Engineers, vol. iii.

GOLD, COLOURING *of.* The bath usually employed for imparting the colour of fine gold to jewellery consists generally of an alkaline nitrate and common salt, to which is added some acid sulphate, like alum, or oxide of iron, so that a dilute aqua regia is

produced. R. WAGNER attempted to substitute dilute aqua regia, but without success. He accomplished his object of obtaining a fine gold colour by using a solution of one gram of bromine and twenty-five grams bromide of calcium—or thirty grams bromide of potassium—in one litre of water. The articles are to be left in the bath three to five minutes, then removed and rinsed with clean water. Alloys of silver and gold are to be rinsed with a solution of hyposulphite of soda.

GOLD, MILLING. Cyanide of potassium acts on mercurial compounds with ferric or ferrous salts in solution, by decomposing them and dissolving their constituent portions, keeping the surface of the mercury metallic, preventing what is commonly known as 'flouring.' Its use is therefore recommended in the process of milling gold. It must be remembered that both gold and silver are not quite insoluble in cyanide. The loss of metal which falls upon the mercury, gold, or silver of these *blanketings* depends, therefore, entirely upon the relative affinity of these metals for this salt.

Mr. SKEY has worked out a list showing the electro-motive order in cyanide of potassium of various metals occurring in gold-fields or being employed for 'milling' gold. It runs from negative downwards to positive:—

Carbon,	Lead,	Platinum,	Gold,
Iron,	Silver,	Arsenic,	Tin,
Antimony,	Copper,	Mercury,	Zinc.

All other ores occurring in nature are mostly negative to the whole series. Thus it is shown that whenever cyanide of potassium is used to assist in the amalgamation of blanketings, the loss falls upon the gold and silver present, the mercury being protected from the action of this salt by these more valuable metals.—'Electro-motive Order of certain Metals in Potassium-cyanide with reference to the use of this Salt in Milling Gold,' by W. SKEY. *Transactions of the New Zealand Institute*, 1876.

GOLD REFINING BY THE USE OF BROMINE. Gold is readily dissolved by bromine, and the bromide of gold is resolved by heat into metallic gold and free bromine. It is therefore a valuable agent for freeing gold from foreign metals, such as lead, bismuth, antimony, and tellurium, which alter its properties. All that is necessary is to add to the gold a certain quantity of bromine.

M. R. WAGNER, in the *Bulletin of the Chemical Society of Paris*, suggests that bromine may replace chlorine in the process of refining devised by MILLER, and in PLATTNER's process for extracting gold, and that it may be made especially valuable in treating the residues of roasted auriferous pyrites.

GOLD AND SILVER EXTRACTED BY THE SECOR EXTRACTING PROCESS. According to the process invented by Mr. CHAS. SECOR, the crushed ore is put in a machine resembling a covered pan. The first introduction of steam is at about 80 or 90 lb. pressure, which heats the mercury, and sends it through the entire mass, and takes up all float gold; the steam is then turned off for awhile and re-introduced at a lower temperature, just sufficient to warm the mercury and cause it to combine with the metals. From 90 to 96 per cent. of the assay value is saved by this process. The machine itself is a strong iron closed cylinder containing a series of mullers, which keep the ore constantly agitated. The object of disintegrating the ore by the steam is to thoroughly prepare the charge for amalgamation, and the pressure and the degree of heat that accompany it are put on according to the general character of the ores to be treated. After being worked for one or two hours at the high pressure required, the steam is shut off, and the pressure reduced through a pipe for that purpose. Quicksilver is put in the charge, everything made tight, and amalgamation commences and ends in one or two hours. When finished all is discharged into settlers, and a new charge put immediately into the machine. Work is going on all the time, for while cleaning up the settler more ore is being treated. The treatment of ores does not necessarily take the length of time mentioned, but varies according to the class. Some ore can be charged in the machine and thoroughly treated as above in one hour and a half. For saving very fine gold in ores, gold that floats and cannot be precipitated, it can be easily understood that in amalgamation the heat of the steam agitates the quicksilver, the mullers carry it up in the charge, bringing it in perfect contact with the metal it is searching for. In treating a sulphuret a pressure of 60 lb. is put on to thoroughly disintegrate, decompose, desulphurise, or drive off the sulphate that holds the gold a prisoner. That effected, amalgamation is easy. A very heavy sulphuret will have to be roasted prior to amalgamation by this method, but it will not be necessary to crush the ore fine before roasting. Desulphurising in a common limekiln furnace, the ore, broken to the size of an egg, is all that will be required, and ore in this way can be roasted in large quantities.

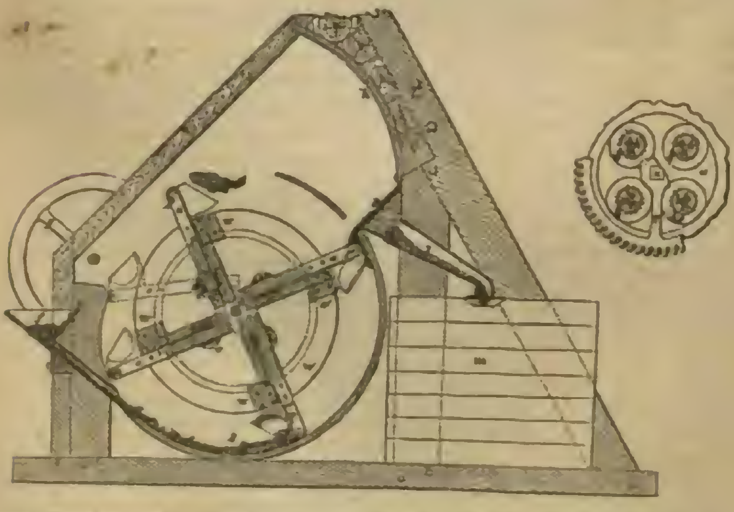
It is stated that very base ores can be treated by the SECOR process raw, and made

to yield about 70 per cent. of fire assay, but with the assistance of a plain fire treatment in addition, the yield will be sufficient to satisfy all reasonable men. With silver ores this treatment is the same, except the very moderate use of chemicals, the cost of which is very much less than in the ordinary open pan process. The supposition is that gold is mechanically combined in the ore; silver, with exceptions, chemically combined with other metals or minerals in the ore, hence the use at times of the addition of fire treatment and chemicals for the successful working and yield of silver ores by an amalgamating process. The quantity of steam used in this machine is merely nominal; the steam once through the pulp with the first pressure on is the largest supply wanted. The continuation of the pressure through the pipe is to supply the trifling amount of steam that condenses. Mr. Secor does not claim to treat all kinds of ore by this method, but tells us that the class of ores he can and has worked successfully with good yield is sufficient to handsomely remunerate him. He says that the process will enable parties to work low-grade ores at a cost that will yield a profit, and that mine owners can have the ores from their mines worked in quantities of from 5 to 10 tons before purchasing the machines.—*The Mining Journal.*

GOLD QUARTZ, *Granulating Machine for, in Australia.* Mr. Edward Alleyne Fitton patents certain 'Improvements in Machinery for Granulating and Pulverising Gangue Minerals and other substances,' the most remarkable of which are machines which he calls the 'lithobolos,' or catapult, the 'balista,' and the 'arbalist.' The materials are placed on a plate or cup of metal, or other contrivance and materials, and by the action of repulsion or recoil of an elastic medium, such as a spring, or by a twisted coil or coils, into which the beam or arm of wood, &c., of sufficient strength is inserted, in such a manner as, when pulled or forced down by a lever, &c., the tension or torsion of the rope is increased, and when let go it of course rebounds or recoils back to its former position, when the matters placed in or held by the arm are dashed or projected against the metallic target, &c., by which means they are pulverised and granulated. The fine powder passes through a screen or screens in the periphery, or in some other position, as shown, and is there passed into a receptacle.

Fig. 2365, drawing of the 'lithobolos,' or catapult pulveriser. *a a a a* beams or arms, to which are fastened cups of metal, &c.; or a hollow is made in the head of the arm (in the wood) to lift and hold the materials to be operated upon, until pro-

2365 2366

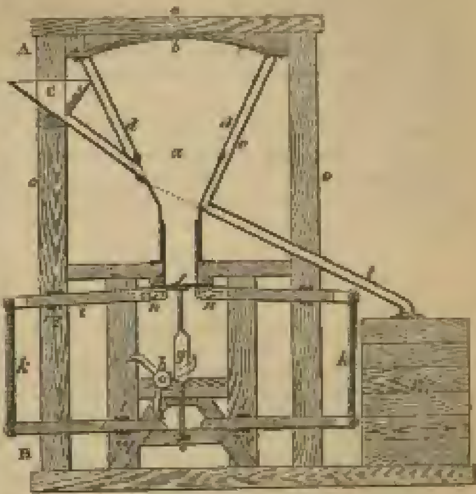


jected therefrom by the recoil, when they are set free from the cam. *a*, by the arm striking against the vulcanised india-rubber or other elastic cushion, *e*, fastened to the strong framework marked *w w*. *b b b b*, framework; *c*, ratchet wheel and pall, or other contrivance for twisting the ropes. *d d d d*, ropes of any material. *e*, axle, with metal fixture; *f*, hopper to feed materials to the machine; *g*, fly wheel; *h*, target, against which materials are dashed and pulverised; *k*, screen, either of one or

more screens working together, through which the fine dust is passed to receiver, m. This may be fixed or caused to oscillate by a rod or other contrivance worked by the gear. *l*, pipe, conveying pulverised material to receiver, *m*; *m*, receiver; *n n*, frame-work; *o*, cam, fixed or not, *as required*; *p p p p*, friction rollers; *s s*, showing materials taken up by cup, and projecting therefrom by the recoil; *w w*, cross pieces of frame. *Fig.* 2366, cog wheel.

Balista Pulveriser is a name given to a machine for crushing gold quartz by the force of blows, the material being beaten against a target by the power with which it is thrown, as from a balista. The following is a description of the patented machine, *fig.* 2367: *a*, cylinder; *b*, target, of any suitable hard material; *c*, hopper to feed; *d d*, strong screen or screens on the interior; *e*, casing of sheet iron, or other suitable material; *f*, plate or small cylinder, working in *e*, to hold materials to be broken; *g*, groove or rod, in which the cam, *h*, works by forcing the plate working in the arms in the twisted coil or coils by a slot, by which recoil of the plate against the elastic cushion, *m m*, and the powerful force of the spring, caused by said coil or coils or other means, the materials are projected against the target with great velocity and momentum, and pulverised, when it passes over the screen or screens and through pipe to receiver, p; *i i i i*, arms; *k*, ropes connecting the arms of the springs, to increase the force of the recoil; *l l l l*, twisted coil or coils; *m m*, cushions of vulcanised india-rubber or any other elastic body which I prefer; *n n*, slots; *o o o*, frames; *p*,

2367



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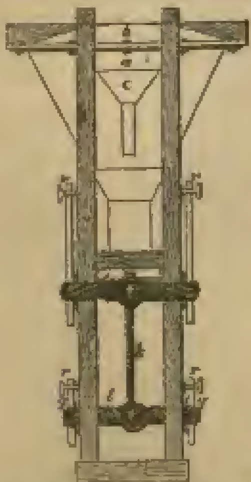

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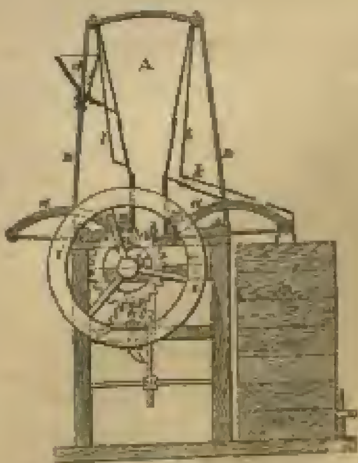


receiver for the pulverised matters; *q q q q*, levers, to twist the coil or coils of ropes; *r r r r*, bolts to restrain levers. *Fig.* 2369, elevation at A B. These machines may be used in a horizontal, vertical, or any other position, as required.

Fig. 2360: A, cylinder; *a a*, steel springs; *b*, bottom plate, in small cylinder; *c c*, screws; *d*, hopper; *e*, target, against which materials are dashed; *f*, rod; *g*, groove in *f*, in which cams work; *h h h h*, cams; *i i i*, gear; *k*, discharge pipe, to receiver; *l l*, sheet iron external casing; *m*, receiver; *n n*, stays to target; *o*, frame; *p*, manhole. *Fig.* 2365, plan.—EDWARD ALLEYNE FITTON'S *Specification*, published by the Patent Office at Melbourne.

GRAPHITE. For the valuation of graphite, M. G. C. WITTSTEIN, in DINGLER'S *Polytechnic Journal*, recommends fusion with oxide of lead; and he conducts the analysis as follows:—

1 gram (15·432 grains) of the finely-powdered sample is heated to low redness, by which water is driven off. The dry substance is fused for half an hour with 3 grams of a mixture of equal molecules of the carbonate of potash and soda, and 1 gram of caustic potash or soda. The fused mass is treated with water, and the filtrate set aside. The portion insoluble in water is digested for some time with hydrochloric acid (the filter ash being added), and the insoluble portion therein collected, washed, dried at a gentle heat, and weighed as graphitic carbon. The acid filtrate is mixed with the aqueous filtrate formerly obtained, the liquid is evaporated to dryness, and silica, iron, and alumina are estimated in the usual way.

GREEK STONE (*Magnesite*). *Carbonate of Magnesium.* STROMEYER gives its analysis—

Magnesia	47·64
Carbonic acid	50·75
Water	1·61

It is found in Upper Styria, in Moravia, in Silesia, and in Piedmont. It is also abundant in the United States and in Canada. See ALKALI MANUFACTURE.

GREEN, ARNAUDON'S. *Chromic metaphosphate.*

GREEN, ADOLFO CASALI'S. He proposes, instead of the expensive chrome greens, to calcine strongly an intimate mixture of 1 part of bichromate of potash and 3 parts of baked gypsum. The result is a grass green mass, which, on boiling with water or mixing with dilute hydrochloric acid, leaves a fine powder of an intense and beautiful green, possessing a very high colouring power.—*Gazetta Chimica Italiana*, anno iv.

GREEN, GUIGNET'S. *Hydrated Sesquioxide of Chrome*, called also Emerald Green and PANNETIER'S Green.

GREEN, LEUNE *and* CASTELHAZ'S. *Hydrated Chromic Oxide.*

GREEN, MATHIEU PLESSY'S. *Phosphate of Chromium.*

GREEN, ULTRAMARINE. *Anhydrous Chromic Oxide.*

GREEN GREASE. One of the products obtained in the distillation of coal tar, which is used for preparing crude anthracen. See ANTHRACEN.

GREEN'S ORE-DRESSING MACHINE. See ORES, DRESSING OF.

GREISEN. A rock composed of mica and quartz, abundant in New South Wales.

GROUND NUT, AFRICAN. See ARACHIS HYPOGÆA.

GUANO. Dr. VOELCKER found that the nitrogen in the Peruvian guano was, on an average, equal to rather more than 12 per cent. of ammonia.

GUANO, FRAY-BENTOS. A new manure, prepared in Fray-Bentos, in the Uruguay Meat Extract Manufactory.

The manure resembles meat flour, being a fine dry powder, smelling of glue. It consists of—

		Mean of two determinations
Water (at 130°)	—	9·24
White ash	—	49·74
Sand	2·64	—
Phosphoric acid	20·07	—
Lime	25·44	—
Magnesia	0·76	—
Sulphuric acid, potash, &c.	traces	—
Organic matter	—	41·03
Nitrogen	4·6?	—
		100·01

This manure was introduced by J. MEISSNER, of Leipsic.

GUANO, AUSTRALIAN. Australian papers state that the Chief Secretary of Victoria has received from the Acting Colonial Secretary of Western Australia a copy of a notice inviting tenders for the removal of guano from the Lacepede Islands, on the

north west coast of that colony, and that the Government offer to grant the exclusive right of removing guano for three years from July 1, 1877, the licensee to take a minimum amount of 40,000 tons during that period on a royalty per ton.

GUM COPAL TREES. *Mti Sandarusi.* In the Consular Report from Zanzibar is an account by Captain Elton of those trees:—

'Leaving the town of Dar-es-Salam, and passing through a clearing of the usual East Coast description, Captain Elton soon reached a spot where the slaves employed in clearing land had come upon an extensive belt of these trees. Their immense size and number astonished him. He measured an average tree, and found it 60 ft. high with the top branches lopped off; the girth at the ground was 4 ft. 3 in., and it was 2 ft. 10 in. at the first branch, above 21 ft. from the ground. On stripping off the bark, the gum was found deposited in many places between it and the wood in a liquid form. Where the tree was injured a resinous gum had collected in considerable quantities, and it was also seen on the lower sides of the branches of several trees; and one of the two slave guides stated that his wife had received a dollar for what she had dug at the foot of a tree where a rotten branch had fallen. It seemed probable that where trees have been left to fall to pieces from old age, large quantities of gum may be found buried. Insects innumerable live on the *Mti Sandarusi.* One branch was cut down, in which a family of ants had formed a large nest behind a wall of the gum, and were rapidly undermining the heart of the wood; and legions of wood-lice as well as ants were to be seen between the bark and the wood. Captain Elton and Lieutenant P. Pullen, who accompanied him, came to the conclusion that the attacks of the swarms of ants and other insects led to the slow but sure destruction of these trees, and that as the heart of the wood becomes undermined, a tree throws out the resinous gum almost, it would seem, in an effort to arrest the process of decay. After the fall of a tree a few years would bury the wreck in the shifting sand which covers the surface of the sienna-coloured subsoil, rich in vegetable remains, in which the copal tree is found. The slaves stated that one could travel for two days into the interior before losing the *Mti Sandarusi*; but Captain Elton says that at the rate at which the clearing progresses, it will not be long before this copal tree wood becomes a thing of the past. Almost all the trees are festooned with the long intertwined ropes of the india-rubber *Uiana*, the thickly-matted cords of which, pendant from the main limbs and knotted into a sort of rigging, supply easy means of ascent to the natives looking for the resinous deposits on the branches. This india-rubber was at one time worked rather extensively here, but was given up as unprofitable in consequence of the number of slave lads carried off by leopards. The slave guides easily worked up two large balls of india-rubber for Captain Elton. After making deep longitudinal incisions in the main ropes of the *Uiana*, they smeared on the left arm the milky substances, which exuded profusely; and when enough had been procured, this was stripped off in flakes and rolled up in the hands until it assumed the shape of a small dumpling. At Dar-es-Salam it commands a price of from $6 to $10 per frasilah of 35 lb.

GUM HOFMANN. In the manufacture of the Hofmann violet, by the action of ethylic or methylic iodide upon rosaniline there is produced a considerable quantity of a dark-coloured resinous substance, to which this name is given.

H

HÆMATINON. A flux of a fine red colour employed in mosaic work. It is prepared as follows:—

Pure quartz sand	60 parts
Oxide of copper	10 ,,
Ferroso-ferric acid	3 ,,
Calcined borax	10 ,,
,, soda	10 ,,

The mixture must be brought to a very high temperature and then allowed to cool to dull redness, at which it is to be kept for some time. The mass is usually covered with a vitreous green slag.—M. R. Kayser, *Poly. Centralblatt.*

HAIR SLAG. See Cotton, Silicate of.

HAÏ-THAO OR HAÏTRA. This is a name given to a new substance introduced for finishing cotton materials. Hai-thao, or gelose, is obtained from an alga, occurring abundantly in Cochin China and in the Mauritius, in the form of coarse flat fibres, which,

when hard and tough, are about 30 centimètres long (2½ centimètres to 1 inch English). It is insoluble in cold water, but dissolves in hot water—after boiling for about ten minutes—forms a transparent, thin, dirty solution, which on cooling deposits a yellowish jelly soluble on boiling. It is insoluble in alcohol, hot or cold. HEILMANN shows that for finishing cotton goods it can only be used in hot solutions, and that it is fitted only for fine textures, soft and firm to the touch, but that it is inferior to dextrin. A dilution of 1 part of the thao with 300 of water is necessary to ensure the fixing of it on the textures. Neither dextrin nor starch fills the thread as perfectly as thao, and these substances produce a much drier texture. It is sold in Paris for 6½ francs per kilo.—*J. J. Heilmann*: DINGL. *Polyt. Jour.* ccxviii.

HARDENED GLASS. See GLASS, TOUGHENED.

HEAT. One of the most important questions which comes under this head relates to the loss of heat in the combustion of fuel, especially the large proportion of fuel which is used in the production of steam. The economical working of a steam-engine is entirely dependent on the weight of steam required for the development of one indicated horse-power; so the economy of the boiler will be according to the weight of fuel required to produce a certain weight of steam at a certain pressure. Thus one of the most important practical questions to be considered in relation to the economy of heat has reference to the best mode of constructing, fixing, and firing the boilers used for producing steam.

The theoretical evaporative power of coal varies from about 11 to 14 lb. of water, evaporated from 212° Fahr. by 1 lb. of coal. The difference between the amount of heat contained by coal, and the quantity utilised in the production of steam, forms a loss which is accounted for in the following ways:—

1st. To the defective construction of boiler and boiler flues, allowing too large a proportion of heat to pass away into the chimney.

2nd. To an excessive quantity of air passing through the fire-place.

3rd. To proper means not being taken to prevent the radiation of heat, &c., from the upper surface of the boiler.

Some experiments made at the Nunnery Collieries, Sheffield, under conditions which tend to reduce the amount of loss from the causes above mentioned, are here recorded for the purpose of showing the small amount of loss which takes place in the cost of a boiler constructed on improved principles.

The boiler used was a double tubular boiler without cross-tubes, the general dimensions being as follows:—

Length	32 feet.
Diameter	7 ,,
Diameter of tubes	2 ,, 9 inches.
Length of grate	6 ,,

Flange plates, forming tubes of smaller diameter, provide the means of expansion in place of rings. Thickness of tube-plates, $\frac{1}{2}$ the in.; thickness of shell, $\frac{7}{16}$ the in. Quality of coal used, Nunnery Colliery Park Gate Hard Coal:—

Units of heat contained by 1 lb. of the coal, as tested by a reliable analyst	13,030
Duration of experiment	6 hours
Quantity of coal used	448 lb. per hour
Quantity of water evaporated	5,133 ,,
Average quantity of clinkers and ashes remaining from above coal	27 ,,
Temperature of feed	165° Fahr.
Indicated pressure of steam on gauge	45 lb.
Average heat at the damper, where the gases finally leave the boiler	375°
Temperature of air in front of and passing into the boiler	102°
Mean temperature of air at the top of and about the boiler	65°

Mean volume of air passing through the flues: 200 feet per lb. of coal consumed.

The above experiment is one of a large number made on successive days, the results of which were nearly all alike. The weighing-machine in which the coal was weighed was carefully tested, and the meters through which the water passed were also tested. The air passing through the flues was measured by an anemometer, and a pyrometer was fixed at the damper.

The level of the water at the commencement and end of each experiment was the same, and the same description of coal as that used for the experiment was used for about an hour before its commencement.

The boiler was fixed upon a plan invented by Messrs. HYDES and BEVERITT, which consists of the following arrangements:—

1. The gases from the coal pass through the two tubes, and then pass under the lower half of the boiler, afterwards returning over the top of the boiler to the chimney. In passing under the boiler the gases do not come direct, but work backwards and forwards through a number of narrow passages formed by fire-clay slabs placed at right angles to the boiler, and the effect of this arrangement is to cause a large quantity of the heat contained in the gases to be left behind.

2. Each fire-place is provided with a small steam jet, which is used immediately after firing, and which is of service not only in preventing the cold air from impinging upon the surface of the tubes, but also in causing a more complete admixture between the air and the gases arising from the incandescent fuel. A door in the bridge, worked by a handle coming to the front of the boiler, is also used, and this being open for a few minutes after firing, prevents the formation of smoke.

The distribution of heat contained by the coal has been carefully calculated, and is shown by the following statement:—

1. Units of heat utilised in evaporating 5,133 lb. of water per hour by the consumption of 448 lb. of coal	5,312,655
2. Units of heat lost by hot air, &c., passing up the chimney	413,075
3. " radiation from the outside surface of the boiler and of the brickwork over the top of the boiler	11,068
4. Units of heat lost by contact of the same surfaces with cold air	10,009
5. " in soot	8,775
6. " ashes	58,635
7. Unaccounted for	23,223
Total	5,837,440

The total of 5,837,440 (12,030 × 448) represents the total quantity of the units of heat contained by the coal used in one hour, as ascertained by actual experiments upon an average sample.

The above experiment shows that so large a percentage as 91·01 of the total heat contained by the coal used was utilised in the production of steam.

Had the boiler been provided with cross-tubes, and had the two main tubes been made of thinner plates, the result might have been still more favourable.—E. B.

HEMP CAKE. This is chiefly used for adulterating linseed cake. See FEEDING STUFFS.

HENWOODITE. A phosphate of copper and alumina. (See LAZULITE, vol. iii. p. 46, and TURQUOISE, vol. iii. p. 1048.) Supposed to be a new mineral found at West Phœnix Mine, near Liskeard, Cornwall, existing in globular masses of a bluish green colour upon limonite.

It was thought to be a variety of Andrewsite or chalcosiderite, but analyses made by Mr. J. H. COLLINS proved it to differ from either of these minerals. He gives its composition as—

Water	18·71
Copper oxide	7·77
Alumina	19·96
Phosphoric acid	53·56
	100·00

The composition of the minerals which this mineral most nearly resembles is thus given by Mr. COLLINS:—

	P^2O^5	Al^2O^3	CuO	MgO	H^2O
Callainite	42·39	30·75	—	—	26·84
Lazulite	46·80	34·00	—	13·20	6·00
Wavellite	34·40	37·30	—	—	28·30
Turquoise	32·60	46·90	—	—	20·60
Henwoodite	54·96	19·93	7·69	—	17·42

Mineralogical Magazine and Journal of the Mineralogical Society, August 1876.

HIDES. See LEATHER.

HOLLYHOCK. Used in adulterating wines. See WINES.

HOPS. *Used in panary fermentation.* To prepare a leaven a handful of fresh hops is boiled in a litre (1·760 pints) of water, and thrown on a cloth. The solution,

sufficient for 12 lb. of flour if used directly, is mixed with maize flour or potato starch, the paste dried, broken up and kept for use in a dry place.

For bread-making a handful of this leaven is put into water with about five handfuls of flour and enough water to make a light paste. The mixture is left over night in a warm place to ferment, and on the morrow mixed with about 10 lb. of flour and water in greater or less quantity as the bread is required to be more or less fermented.

It would therefore appear that hops contain an alcoholic ferment capable of resisting boiling water.—M. SACC, *Comptes Rendus*, lxxxi.

HORNBLENDE. (Vol. ii. p. 806.) See LAVA.

HORSEHAIR, VEGETABLE. See CHAMÆROPS HUMILIS.

HOT BLAST. See IRON.

HYACINTH. See ZIRCON.

HYDNOCARPUS WIGHTIANA. A native of Ceylon and the Malabar coast of India. Its fruit is about the size of an apple, the seeds yielding a quantity of fatty oil. The oil obtained is of a greenish colour, somewhat similar to cajuput oil. It is in many respects like the chaulmoogra oil. The boiled oil is of a deep green colour—with acid it first turns Sienna brown, and afterwards to a light brown.

The seeds of *Hydnocarpus* cannot be mistaken for those of *Gynocardia*; they are much smaller, flatter, and of a dirty white. The kernel of both seeds is a dark brown.—W. DYMOCK, *Pharm. J. Trans.* vi. See CHAULMOOGRA OIL.

HYDRAULIC PRESSURE, *employed for loading and unloading cages of coals.* See COALS, *raised by Hydraulic Pressure.*

I

ICE and **ICE-MAKING.** See REFRIGERATION and REFRIGERATORS.

IFE. A name given to one of the bow-string hemps, from Angola. See SANSEVIERA and TEXTILE MATERIALS.

INDIA or **CHINA INK.** Although the Chinese prepare their ink from the kernel of some amygdalaceous fruit, yet, by the aid of our present chemical appliances, we are able to produce a composition in no way inferior to the best China ink by the adoption of the following formula:—

Calcined lampblack	100 parts
Boghead shale black, in impalpable powder	50 ,,
Indigo carmine, in cakes	10 ,,
Carmine lake	5 ,,
Gum arabic (first quality)	10 ,,
Purified oxgall	20 ,,
Alcoholic extract of musk	5 ,,

The gum is dissolved in 50 to 60 parts of pure water, and the solution filtered through a cloth. The indigo carmine, lake, lampblack, and shale black are incorporated with this liquor, and the whole ground upon a slab, with a muller, in the same manner as ordinary colours; but in this case the grinding takes much longer. When the paste is thoroughly homogeneous, the oxgall is gradually added, and then the alcoholic extract of musk. The black is allowed to dry in the air until it has acquired sufficient consistency to be moulded into cakes, which in their turn are still further dried in the air, out of the reach of dust. When quite firm, these cakes are compressed in bronze moulds, having appropriate designs engraved upon them. The moulded ink is then wrapped in tinfoil, with a second envelope of gilt paper. The ink which has been prepared in this manner possesses all the properties of the real Chinese article. Its grain is smooth; it flows very well, mixes perfectly with many other colours, and becomes so firmly fixed to the paper, that other colours may be spread over it without washing it out.—RIFFAULT, *On the Manufacture of Colours.*

INDIA-RUBBER. See CAOUTCHOUC. (Vol. i. p. 691, &c.) AFRICAN.—The production of a giant tree creeper (*Landolphia florida*?) growing in considerable quantities north of the river Congo.

The plant that produces it very commonly covers the highest trees, principally on those near rivers or streams. Its stem is sometimes as thick as a man's thigh, and in the dense wood of Quilella Mr. MONTEIRO says he has seen a considerable extent of forest festooned down to the ground, from tree to tree, in all directions with its thick stems, like great hawsers; above, the trees are nearly hidden by its large, bright, dark green leaves, and studded with beautiful bunches of pure white star-like flowers, mostly sweet scented. Its fruit is the size of a large orange, of a yellow

colour when ripe, and perfectly round, with a hard brittle shell; inside it is full of a soft reddish pulp, in which the seeds are contained. This pulp is of a very agreeable acid flavour, and is much liked by the natives. Every part of this creeper exudes a milky juice when cut or wounded; but, unlike the india-rubber tree of America, this milky sap will not run into a vessel placed to receive it; it dries so quickly as to form a ridge on the wound or cut, which stops its further flow. The blacks collect it, therefore, by making long cuts in the bark with a knife, and as the milky juice gushes out, it is wiped off continually, and smeared on their arms, shoulders, and breasts, until a thick covering is formed; this is peeled off their bodies and cut into small squares, which are said to be boiled in water. From Ambriz the trade in this india-rubber quickly spread south to the river Quanza, from whence considerable quantities are exported.—*Angola and the River Congo*, by JOACHIM JOHN MONTEIRO, 1875.

BRAZIL.—Consul GREEN, reporting on the trade of the Brazilian provinces of Para and Amazonas, states that the crop of india-rubber, which was little over 2,000 tons in 1861, has been steadily increasing ever since, and reached 6,763 tons in the year 1875. He is able to add that there are vast india-rubber yielding districts which have never yet been touched, and that if the rumours that the old districts are becoming exhausted should be correct, there is no reason why the yearly collection should not, in ordinary seasons, continue the steady increase it has shown for some years past, so long as there is an outlet for the produce in the European markets. The increase in 1875 was less than usual, but he observes that this was owing to an exceptionally long rainy season and much sickness, and must not be taken as a criterion of a diminution of population or an unwillingness of the inhabitants to work.

The produce market of Aracata, Brazil, has, ever since July 1874, been furnished with considerable quantities of india-rubber: the exports of 1874 amounted to 265 bales of 170 lb. each, chiefly sent to Ceara and Pernambuco for shipment. It is the produce of *Hancornia Speciosa*. If the people of the interior where the milk of the *mangabeira* is collected knew how to prepare the rubber properly from the juice or milk, no doubt the newly-discovered material would soon be followed by improvement. It fetches a far higher price than any other native produce brought to market, as much as 900 reis per kilo. being paid for good and dry qualities. The country where it is gathered and prepared is about 100 English miles distant, and the trees cover a hilly district of 36 leagues long by about 4 leagues broad.—The *Journal of Applied Science*.

INDIGO, EXTRACT OF. A correspondent of the *Chemical News*, January 1876, says: To make what is generally called *Sour Extract of Indigo*, mix 5 lb. of best Bengal indigo in 30 lb. of strong oil of vitriol. Let it stand for five days: then put it in a tub, and add 40 gallons of boiling water to it; then filter while hot through strong felt cloth. The filters are usually made in this way. A frame like a table-top, 8 yards long and 2 yards wide, is divided into four filters. Pieces of wood across are put on the top, and made to fit the holes (the shape of the bowl, with small holes perforated in them); then the felt cloth is put on the top, and the liquid is poured on it. The sediment at the top is used to colour pottery mould. The fluid which runs through is mixed with 40 lb. of common salt, and digested for six hours; it is then returned to the filters again for four or five days. That which is left on the filters is the extract.

To make *Free Extract of Indigo*, put 100 lb. of the sour extract in a tub with 12 gallons of water. Neutralise the acid with strong soda-ash liquid; then put it on the filters for six days. The matter left on the filters is the free extract.

INDIGO, used to adulterate wines, and its detection, see WINES.

INDIGO DYEING FOR WOOL. *The Hyposulphite Vat.*—Bisulphide of soda is used in solution at 8° B.; 100 litres are poured into the air-tight agitation cask, with 7 kilos. of zinc powder, and stirred for twenty minutes. The liquid, which is now converted into hyposulphite, is drawn off into a pair of large closed tubs, containing milk of lime, formed of 1 part lime to 5 of water. The liquids are well mixed in these tubs, and allowed to settle till the supernatant solution of hyposulphite is quite clear and slightly alkaline.

Of this liquid 40 litres are taken to 1 kilo. of ground indigo. This weight of the colour, ground wet, is placed in a tub holding about 50 litres. The 40 litres of hyposulphite are added, and the whole heated to 60° C. One or two litres of milk of lime are then added, and, if needful, a few more litres of the hyposulphite, until the mixture is a fine yellow. Lime plays an important part in the reduction of the indigo, and must be used with caution. The reduced indigo is then poured into the vat, which contains merely water, but which, after the introduction of the indigo, must have a slightly alkaline reaction. From time to time, therefore, the addition of milk of lime is necessary. If too much lime is added, the wool feels harsh when taken from the vat, and the indigo is not fixed, being capable of removal by washing with soap.

When this happens, acid must be added to the vat.—REIMANN'S *Färber Zeitung*, No. 19, 1875. *Chemical News*, July 2, 1875.

INK. (Vol. ii. p. 914.) RUNGE discovered in 1848 that a dilute solution of the colouring matter of logwood, mixed with some neutral chromate of potassium, made a very perfect ink if kept from the air. On exposure to the air, in the inkstand, it sometimes decomposes very rapidly, its colouring matter being deposited in the form of large black flakes, which leave a colourless liquid above them. This gelatinisation is a defect in this ink, particularly as the precise conditions that determine it are not known. Different means have been proposed to prevent this action; the best seems to be that of the addition of carbonate of sodium recommended by BÖTTGER. To prepare this ink, take extract of logwood 15 parts, water 1,000 parts, crystallised carbonate of sodium 4 parts, neutral chromate of potassium 1 part. Dissolve the extract of logwood in 900 parts of water, allow it to deposit, decant, heat to ebullition, and add the carbonate of soda; lastly add, drop by drop, with constant stirring, a solution of the neutral chromate of potassium, in 100 parts of water. The ink thus obtained has a fine bluish black colour; it flows well from the pen, and dries readily. The chrome ink powder of PLATZER and the acid ink of PONCELET are imitations of the original ink of RUNGE. This ink of RUNGE is remarkably fitted for steel pens.

IRON ORE. ALGERIA. The most remarkable Algerian iron mine is Mokta-el-Hadid. The hill of Mokta, in which this mine is situated, lies on the side of the Lake Fetzara, at the foot of the chain of mountains running north and south, and turning eastward almost to the port of Bona, from which the mine is distant about twenty-two English miles.

The importance of this mine is shown by the fact that in 1874 it shipped from the port of Bona no less than 420,000 tons of ore, representing 260,000 tons of metallic iron. The entire production of steel in Great Britain did not exceed 500,000 tons per annum, and this mine is said to be capable of furnishing one-quarter of the entire yearly make of steel in Europe. The present adventurers have opened out also the mines of Karezza, Bou-Hamra, and Marouania.

Although the name of the mine, Mokta-el-Hadid (the iron pass), indicates that this deposit has, no doubt, been known from ancient periods, still there does not appear to have been any evidence to show that it had been worked upon before 1840, and then not on an extensive scale until the COMPAGNIE DES MINES DE MOKTA-EL-HADID was formed, with a capital of 600,000*l*.

The iron deposit crops out to the surface on the sides of an elbow formed by the hills on the northern bank of Lake Fetzara. See *Annuaire de l'Association des Ingénieurs sortis de l'École de Liége*, vol. iv. p. 182, for a paper read by M. RUCOUX entitled 'Note sur le gisement et l'exploitation de minérai de Fer de Mokta-el-Hadid.'

In 1875 the actual quantity of ore extracted from these mines amounted to 414,368 tons, the quantity actually delivered to purchasers being 399,612 tons.

The iron ore returned as imported into this country in 1875 from Algeria was 55,820 tons, of the value of 61,808*l*.

The other iron mines in Algeria are:—

CAMÉRATA, on the Djebel Aouaria, which forms the promontory on the maps, Cape Oulassus. It is expected that this mine will soon produce 200 tons a day.

BENI-SAF, near to Camérata, now having 323 men at work.

GOURAGES, worked by the COMPAGNIE DES FORGES ET FONDERIES DE CHÂTILLON ET COMMENTRY.

AIN-SADOUNA, worked by the same company.

DJEBEL HADID, near Ténès, now worked by an English company, especially on the lodes of Oued Masselmoun.

The HILLS OF BENI AICHA, near Novi, are important iron ore deposits.

ZACCAR is worked actively, and sends off excellent ore to Algiers and Oran.

DEPARTMENT OF CONSTANTINE.—Thirteen mining concessions are granted; nine are at work (1876).

DJEBEL FILFILAH, making trial workings.

SIDI-SAFI, an open quarry, producing a manganiferous iron ore.

OUED MASSELMOUN. A new brand of pig iron (K. H. Messelmoun) is now being produced by the WIGAN COAL AND IRON COMPANY from very pure ores, produced from this their own iron mine in Algeria.

AFRICA.—Commander CAMERON has, in his 'Across Africa,' many interesting notices respecting iron. We extract two or three of them:—

'In Kwasèrè there were two or three small foundries about 12 ft. square, with a raised bank round the sides, the centre of the floor sloping towards a deep trough, which was placed to receive the molten metal. The remains of a furnace lay in one corner, and clay nozzles for the wooden bellows were scattered about in all directions.

The whole of the floors of these foundries were well plastered with smooth and polished clay, burnt quite red in many places.

'At the village of Manyara, in which, standing amongst many others, ironworks were found. All had two or three foundries in them, upwards of 30 ft. long by 20 wide, with low walls, and an enormously high roof. In the centre was a pit, 6 ft. wide, 4 deep, and 20 long, rather shallower at one end than the other. Across this, about 6 ft. from the shallow end, was built a clay furnace 4 ft. wide. The smaller of the two divisions of the pit was used as a stoke-hole, whilst the ore and the slag ran into the other, and round the sides were small divisions containing charcoal and iron ore. They sometimes use as many as a dozen pair of bellows at one time in order to make a sufficient blast. Their bellows are formed of two upright and parallel shallow wooden cylinders with vents leading into one nozzle, which is protected by clay from the effects of the fire. These cylinders are covered with grass cloth having a stick 3 ft. long fastened into the centre, and are worked by holding one stick in each hand and moving them up and down alternately as fast as possible. By this means a good and continuous blast is produced. After smelting, the iron is worked by smiths into small pieces weighing about 2 lb., and shaped like two cones joined together at the base, and a piece or rod the size of a large knitting needle projects from both ends. In this form the metal is hawked about for sale. Small open sheds are used as smithies, and the anvils and large hammers are made of stone, but small hammers are of iron. These of stone are provided with two loops of rope to serve as handles, while the iron hammers are simply grasped in the hand and are without handles. . . . Two days' marching from Manyara brought us to Kwakarongo. On our way we passed a hill composed almost entirely of black speculum iron ore, and a curious mount of precipitous cliffs, which formed one side of it, rose sheer out of the plain.

'The Lovale country, which is divided into districts, governed by distinct chiefs, is spoken of as abounding with foundries, and where the majority of the men work in iron. In this district Captain CAMERON noted a wonderful variety in the construction of the huts; they were square, round, and oval, having high roofs, in some instances running into two or three points. At the village of Sha Helembe, chief of the last district in Lovale, Captain CAMERON writes:—"Near the camp was a small and peculiarly shaped furnace for smelting iron, and I was told that the greater portion of the iron worked in Lovale was smelted at this place. The ore is found in the form of large nodules, in the river-beds, whence it is dredged up at the termination of the dry season."

'In Lovale, generally, the people import iron in large quantities from Kibokwé, and work it cunningly into arrow-heads of fantastic forms, and into very prettily ornamented hatchets. The hatchets are also very ingeniously contrived, the upper part of the blade or tang being round, and it may be placed in the handle to serve either as an edge or axe.'

A little further on his journey he writes:—'West of Lovale is the country of Kibokwé, where the rise out of the central depression becomes very marked, and the country is nearly all covered with forests. . . . The people work iron tastefully and well. They obtain the ore from nodules found in the beds of the streams.'

In the appendix to the second volume CAMERON summarises the natural products of the country; and in this manner deals with iron:—'Amongst minerals, iron takes the first place. It is worked in the north-west portion of Unyanyembé, whence it is carried in all directions. Hoes made there are even exported to the coast by down caravans. Hæmatite ore is common all about the country of Unyamwési, and is found in Uhidjwa and Uhiya, as also about Munza, in Uma. In Manyuéma there is a beautiful black speculum ore in great quantities, and the iron produced from it is much valued. Dr. LIVINGSTONE also discovered much iron to the westward of Lake Nyassa. The Kibokwé nodules of ore are dredged up from the streams.'

CANADA.—*Meteoric iron* was found in 1854 at Madoc. The mass weighed 370 lb., and contained 6·30 per cent. of nickel. Other masses have also been found in the North-West Territory.

Magnetic Ore.—In the Lakes Superior and Huron region magnetic iron ores occur in large quantities:—To the south of Nequaquon and Gun-flint Lakes massive crystalline ore was found. In the north-west corner of Neebing, interstratified with sandstone (containing 37·72 per cent. of iron); and one to two miles west of the mouth of Little Pic River a deposit 90 ft. thick, chiefly a silicate, containing metallic iron from 36 to 46 per cent. At Portage, the west end of Little Long Lake; at Gros Cap, mouth of Michipicoten River, and at the Mammoth and Vulcan Iron Mountains, about eight miles north of Batchewana Bay, large quantities of fine-grained magnetite, averaging about 50 per cent. of iron.

This ore is also found in Texada Island, in Thunder Bay, Lake Huron, at Peterborough. Professor CHAPMAN, of Toronto, says this ore occurs in beds which have a possible aggregate thickness of 50 or 60 ft., and he gives the following as an analysis of an average sample of the ore:—

Sesquioxide of iron	58·35	Metallic iron 60·13
Protoxide of iron	24·87	
Alumina	0·42	
Titanic acid	0·73	
Oxide of manganese	0·13	
Magnesia 2·50, Lime 1·43, Silica 11·17 — Rock matter	15·10	
Phosphoric acid	0·17	
Sulphur	0·04	
	99·87	

The following are analyses of magnetic ores from the Hull Mines (Laurentian) by Dr. Sterry Hunt:—

	Red ore	Black ore
Peroxide of iron	66·20	73·90
Protoxide of iron	17·78	
Oxide of manganese	traces	none
Alumina	—	0·61
Lime	1·55	none
Magnesia	0·18	1·88
Phosphorus	0·015	0·27
Sulphur	0·28	0·85
Carbonic acid	1·17	—
Silica	11·11	20·27
Graphite	0·71	—
Water	—	3·27
	99·295	100·042
Metallic iron	60·17	53·51

The ore frequently contains scales of graphite. In the blast furnace it yields from 60 to 62 per cent. of iron.

An iron ore found on the banks of the Moisic River, in the province of Quebec, on the north side of the Gulf of St. Lawrence. It is a fine black sand, and by analysis is found to be half magnetic ore. M. Poirsat gives the following analysis:—

Magnetic oxide of iron	51·12
Protoxide of iron	34·60
Titanic acid	11·27
Silica	3·01
	100·00

Iron Sand.—Many of the rocks in the great Laurentian series, which is extensively developed to the north of the Gulf of St. Lawrence, contain small disseminated grains and crystals of magnetite and ilmenite, which, on the disintegration of the rocks, are gathered together by natural processes of concentration, and form important deposits of 'iron sand,' stretching in some cases along the coast for many miles. Some of them are of recent origin, but others belong to the post-pliocene age, and are found as high as 100, and even 200, ft. above the tide level of to-day.

Red Hematites.—This ore of iron is abundantly distributed over Canada. Extensive mines are worked at about five and a half miles north-east of Thunder Bay, Lake Superior, and at Loon Lake, on the north side of the Desert Lake, at Madoc, Dalhousie, and about a mile from the Lac des Chats.

Besides the above localities for hematite in the Lakes Superior and Huron region, the following are worth mentioning, the quantity in each case apparently indicating an economic value:—East side of Lake Nipigon, near the mouths of Ouimiuisagi or Red Paint River, and of the Sturgeon River, slaty hematite ores (a specimen from the latter place was found to contain 36·06 per cent. of iron, and to be of such a nature as to render it easy of reduction); hills east of Lake Nosswatanose, Black Sturgeon River (a red earthy hematite); west point of the largest of the Slate Islands (impure slaty ore); near Wallace mine, Lake Huron (in combination with magnetite); about ten miles up the east branch of the Montreal River, Ottawa valley (veins of specular iron in quartzite); foot of Big Rapids, below the Long Portage, south branch of Moose River (a large deposit of siliceous carbonate of iron passing into hematite).

Specular Iron Ore.—This occurs in Londonderry, on the west bank of Cook's Brook. The Report of the Geological Survey of Canada (1873–74) gives the following analysis:—

Peroxide of iron	96·93	Metallic iron 67·85
Protoxide of manganese	traces	
Alumina	0·33	
Lime	0·04	
Magnesia	0·11	
Phosphoric acid	00·07	
Sulphur	none	
Water, hygroscopic	0·03	
Water, combined	0·79	
Insoluble residue	1·26	
	97·256	

Limonite and Bog Iron Ore.—This ore occurs abundantly near Londonderry, and has been worked by The Steel Company of Canada.

A most important vein of iron ore occurs in the Middle or Upper Silurian slates and quartzites of Londonderry, on the southern slope of the Cobequid Hills. It has an approximately east and west course, and has been traced for a distance of more than twelve miles. The largest proportion of the ore, so far as known, consists of limonite, which is generally earthy, but sometimes occurs in lustrous stalactitic and mammillary forms. It has evidently been derived from the alteration of spathic ore and ankerite, both of which are in many places found in an unaltered condition. The following analyses (*Report of the Geological Survey*, 1873–74, pp. 231, 233) will serve to illustrate the composition of the limonite:—

	Ochrey Limonite	Compact Limonite
Peroxide of iron	79·68	84·73
Protoxide of iron	—	traces
Protoxide of manganese	2·51	0·23
Alumina	0·63	0·23
Lime	0·57	0·14
Magnesia	0·34	0·14
Silica	3·05	—
Phosphoric acid	0·44	0·19
Sulphuric acid	0·01	0·01
Water, hygroscopic	0·78	0·33
Water, combined	11·65	11·07
Insoluble residue	—	2·67
	99·66	99·74
Metallic iron	55·78	59·31

Mining has been carried on since 1849, and a charcoal blast furnace was erected in 1853, which has, at short intervals, been in blast ever since, with a production of between 30,000 and 40,000 tons of pig iron from about 70,000 tons of ore (chiefly limonite). In 1873 the mines, blast furnace, forge, casting house, steel works, &c., together with large tracts of land covered with fine hardwood forest, were sold by the Acadia Charcoal Iron Company to the Steel Company of Canada, and since then two Siemens' rotatory furnaces for the production of steel direct from the ore have been erected. Two new blast furnaces in which the ores will be smelted with coke are also (1876) in process of construction. When completed they are to be 63 ft. high, 19 ft. in diameter at the boshes, and 5 ft. at the hearth. In 1875, about 300 men were employed in the mines.

Clay iron stones have been found a little north of North Saskatchewan river, from about two miles below Edmonton, and occurring in connection with a bed of lignite. Similar ores are found at many places along the Saskatchewan from Rocky Mountain House to Victoria, and at the latter locality both lignite and iron stones occur in beds of considerable thickness. Further to the south-east also, iron stones are widely distributed, generally in connection with the Tertiary lignites, in beds which are mostly thin, and in nodules sometimes weighing several hundred pounds. The average percentage of iron in several specimens from near Fort Edmonton is 34·98. A specimen from the Dirt Hills contained 41·49 per cent. of iron, 1·15 of protoxide of manganese, ·057 of phosphorus, and ·06 of sulphur.

China.—In one of the valuable Consular Reports published by our Government, we find the following very interesting particulars of the iron industry of China:—

'The best ore in China comes from Mia-kou-tzu, a mine about 70 li to the south of Pen-hsi-hu. In this neighbourhood there are several mines, from which a large quantity of excellent ore is produced. The prices are stated to be as follows:—

100 catties of ore from Miao-kou-tzu, 1·70 tiao (11½d.), 100 catties of ore from Ta-pao-ling, 1·30 tiao (8¾d.), and ditto from Tai-kou-tzu, 1·20 (8d.). The Ta-pao-ling ore is said to yield 40 per cent. of iron. In the works visited by the Consul they employ over 200 men; and there are six or seven other firms of the same nature and of nearly equal size, in addition to many smaller establishments, where the iron cast in the foundries is wrought into agricultural implements of every description, nails, horseshoes, &c. The moulds used after the ore has been subjected to the furnace for the first time are of clay; they are made at a pottery in connection with adjacent clay pits. In addition to the iron mines of this district (New-chwang), coal mines are actively worked along the whole extent of the district, giving employment to a considerable number of hands. The most important of these mines is called the Ma-chin-kou. This employs 300 men, and is about 400 ft. in length. The labour of the miners is said to be very severe, and the men work without other clothing than a covering for the loins. They are mostly paid by the number of baskets they bring up from below, and a strong man is able to earn about 2 tiao (1s. 1½d.) in the course of a day. They have no fixed engagements, but may come and go as they please. The lowest prices for coal at this mine are stated to be about 1·60 tiao per 100 catties (10¾d. per 133⅓ lb.), while the highest figure was about 2 tiao (1s. 1½d. per 133⅓ lb.). This is for the best kind of coal. The mines at Pen-hsi-hu are larger and more numerous than those of Hun-tzu-ling; the former place is generally known as the great coal-producing district of China. The coal is here worked by a great number of different and independent firms, some having only one shaft, and employing as few as ten or a dozen hands. But there are several large establishments. The largest is called the Chu-hsing-fu, and employs over 2,000 men. Seven pits or shafts, with separate entrances, are worked by the owners of this mine. These shafts are all near each other, on the same hill-side, and are almost identical in size and construction. Their average length is said to be about 600 ft. There is frequently, but not always, a shed or small house covering the mouth of the pit. The latter consists of a single shaft, which runs down at a slant of about 45 degrees. None of the shafts are perpendicular, and all the coal is carried up along the inclined plane by a set of men to whom this duty is specially assigned. Their load is packed into two baskets, which are attached to the ends of a short carrying-pole borne upon the left shoulder. The shaft of the Chu-hsing-fu establishment is nearly seven feet high the whole way; the breadth is about the same. It is solidly supported on all sides by the trunks and branches of trees, which are cultivated for the purpose on the hills around. Strong perpendicular beams of fir on both sides support a strong roof of the same material, while below the wood is so arranged as to form steps along the whole of the incline to the bottom. In returning from below with his load, each miner makes use of a small curved staff, which he carries in his right hand, to catch the projection of the steps above, and in this way he supports and pulls himself along in his laborious ascent. The land on which these mines are situated is the property of two Chinese, named Siu and Hau, who rent it to the head of the mining firm for a fixed annual payment. The firm works the mine, and deals with the native coal merchants, whom he supplies wholesale with the best coal at the rate of something over 1 tiao per 100 catties (6¾d. for 133⅓ lb., or say 9s. 5½d. per ton). It is stated that there are no duties of any kind leviable upon the coal, either at the mine itself, along the road, or at the markets whither it is sent. A very large quantity of coal is also consumed in the district in connection with the large iron foundries, potteries, &c. It is satisfactory to note that in these mines accidents of any kind appear to be of extremely rare occurrence, and that their management seems to be excellent.'—MR. CONSUL CAINE *writing to* EARL GRANVILLE *from Hankow.*

GREAT BRITAIN AND IRELAND. (Vol. ii. p. 918, &c.). There is but little to be added to the descriptions already given of the varieties of iron ores produced in these islands. A curious deposit of new hæmatite has been worked at Winford, near Bristol. At Abbotsbury, near Westbury, Wilts, new deposits of iron ore have been discovered, and it is proposed to construct a railway to the place. In some places the bed is said to be 30 ft. thick.—*Iron and Coal Trades Review*, December 15, 1876. A new iron mine is being developed near Lerwick, in the Shetland Islands. The COLTNESS IRON COMPANY have also been opening out some brown ore deposits in Ayrshire. The following Tables will show the progress of the development of our iron mines during the past three years.

It may prove convenient to place here the total quantities of iron ore mined in previous years:—

	Tons
1870	14,508,325
1871	16,334,888
1872	15,584,367
1873	15,294,453

Iron Ore in Great Britain and Ireland (not Argillaceous) in 1876.[1]

Counties, &c.	1874 Quantities	1874 Value	1875 Quantities	1875 Value	1876 Quantities	1876 Value
	Tons cwt.	£ s. d.	Tons cwt.	£ s. d.	Tons cwt.	£ s. d.
Cornwall	43,093 12	34,076 6 6	11,403 13	6,801 9 0	18,380 0	10,808 18 0
Devonshire	21,313 8	16,358 5 8	10,804 1	7,963 0 0	9,036 10	5,078 13 0
Somersetshire	41,343 7	30,367 10 0	43,163 17	23,186 2 0	44,299 5	31,110 2 6
Gloucestershire	171,438 0	148,910 0 0	111,825 16	71,760 13 0	116,068 5	77,804 3 0
Wiltshire	86,630 0	17,891 0 0	87,182 0	21,888 0 0	83,067 0	20,960 5 0
Oxfordshire	38,008 10	7,721 10 0	31,868 0	6,913 12 0	26,140 0	5,228 0 0
Leicestershire	2,890 0	868 0 0	—	—	—	—
Northamptonshire	1,066,178 11	180,186 14 0	1,065,[illegible] 16	172,412 3 2	1,161,130 10	173,808 10 0
Lincolnshire	463,258 18	92,617 16 0	673,300 0	101,260 0 0	573,574 18	161,022 19 0
Shropshire	398,350 10	88,421 4 0	340,868 0	143,419 0 0	—	—
Derbyshire	238,293 0	138,173 4 0	219,132 0	86,438 10 0	—	—
Nottinghamshire	229 0	186 10 0	11,730 0	7,343 0 0	—	—
Warwickshire	92,314 0	80,328 0 0	97,400 0	48,720 0 0	—	—
Staffordshire, North	1,032,303 0	731,062 8 0	[illegible] 12	680,701 0 0	10,998 13	14,[illegible] 10 0
" South	141,804 18	84,734 19 0	718,431 0	909,[illegible] 0 0	—	—
Lancashire	914,887 7	1,133,898 12 0	834,484 0	628,863 0 0	984,160 18	728,805 18 0
Cheshire	1,000 0	600 0 0	1,000 0	780 0 0	—	—
Cumberland	1,110,666 2	1,375,601 0 6	1,147,968 6	880,976 0 0	1,350,810 9	990,846 3 6
Westmoreland	804 0	350 0 0	—	—	—	—
Yorkshire, North Riding	6,614,323 11	1,694,918 13 0	6,121,791 2	1,532,388 17 6	6,062,000 0	1,162,020 0 0
" West Riding	270,900 7	184,074 4 0	253,882 0	130,049 0 0	—	—
Northumberland and Durham	132,440 17	73,831 19 0	60,815 13	37,017 0 0	34,301 12	14,891 16 0
North Wales	47,222 9	72,703 4 0	42,184 0	21,093 0 0	—	—
South Wales and Monmouthshire	681,616 10	339,878 1 0	496,840 3	347,930 0 0	83,060 13	41,484 17 0
Isle of Man	1,143 18	787 5 10	—	—	—	—
Scotland	2,119,771 0	793,161 0 0	2,438,338 0	930,673 0 0	5,3[illegible]6 8	3,412 11 0
Ireland	140,360 6	112,060 0 0	128,609 0	81,831 13 0	11[illegible]06 1	60,71[illegible] 12 8
	—	—	—	—	11,182,100 14	3,410,771 19 8
Iron ore (argillaceous and black band) worked under the Coal Mines Regulation Act	—	—	—	—	5,[illegible],433 0	3,378,[illegible] 6 0
Total iron ore production of the United Kingdom	14,844,936 10	7,312,146 3 8	15,821,060 2	[illegible],073,410 0 8	16,841,283 14	6,[illegible] 4 5
'Burnt ore' from cupreous pyrites	358,000 0	—	300,000 0	—	300,[illegible] 0	—
Iron ore imported	754,141 0	—	488,[illegible] 0	—	672,[illegible] 0	—
Total of iron ore smelted in the United Kingdom	15,[illegible],077 10	—	16,[illegible],783 3	—	17,813,818 14	—

[1] See page 444 for Argillaceous Iron Ore.

Inspectors' Returns of Argillaceous Iron Ore in 1875, and the Mining Record Office in 1876, made under the Coal Mines Regulation Act.

	1875	1876
	Tons	Tons
Cumberland	261	—
Northumberland and Durham	12,008	82,474
Denbighshire	10,151	—
Lancashire, West	1,000	1,178
Yorkshire, West	230,782	381,463
Lincolnshire	116,770	—
Derbyshire	90,396	199,908
Leicestershire	161	
Nottinghamshire	6,052	15,406
Warwickshire	64,092	92,588
Shropshire	464,440	239,163
Staffordshire, North	1,700,000	952,212
" South	384,065	645,288
Breconshire, part of	64,164	—[1]
Glamorganshire, part of	94 }	1,055
Gloucester, Bristol District	290 }	
Monmouthshire	157,665	—[1]
Somersetshire	1,096	2,054
Cheshire	—	1,750
Wales, North	—	40,962
Wales, South	176,610	476,285
Scotland, East	803,065 }	2,547,327
" West	1,542,002 }	
Ireland	900	—
Total	8,033,053	5,659,423

Total Iron Ore production of the United Kingdom in 1876, and other Ores used in our Iron Manufacture.

	Tons
Iron ores—Red and brown hematites, &c.	11,152,160
" Argillaceous ores	5,659,423
" Foreign ores imported	672,235
" Purple ore—from the coppery *pyrites* burnt in this country	300,000

Ireland.—At a meeting of the Royal Geological Society of Ireland (November 1876), Mr. C. R. Tichborne read a paper on the occurrence of magnetic iron ore at Kilbride, county Wicklow, on the property of Mr. W. R. O'Byrne, M.P., with the object of recording a fact and of carefully fostering any possible addition to the mineral resources of Ireland. He described the ore as forming a vein certainly two miles, and, according to indications, three miles long, with a width varying to about 6 ft. in some parts, and a supply reported to be very extensive. Specimens of the surface ore which he submitted for examination were a loose and friable sand, more or less spongy, but perfectly free from organic remains. As the vein was pursued in a more vertical direction, it became more compact, until a dense ore with a specific gravity of 4·37 was arrived at. The silica, which in large quantities made magnetic ore useless for smelting, was extremely low in this ore.

We are indebted to Professor Edward Hull, F.R.S., Director of the Geological Survey of Ireland, for the following interesting particulars respecting the hematitic ores of Cavan and Longford:—

'The Lower Silurian rocks of Longford and Cavan were known, for some time past, to have possessed such ores; but, until railways communicating with shipping ports were constructed, there was little prospect of these ores being turned to profitable account. This obstacle has now been overcome, and the hematite ores are now sent by the Midland and North-Western lines to be shipped at Dublin and Dundalk to the iron furnaces of the North of England and Wales.

'These ores are known to exist in at least four localities, three of which lie in the

[1] Included in South Wales.

district between Granard and Carrick-on-Shannon, and another in the district between Cavan and Ballybay.

'South of Arvagh, on the western banks of Lough Gowna, the ore is being worked, and is brought, partly by boats and then by a branch line of railway, into connection with the Cavan Junction and Midland Great Western Railway. This ore, and that of the localities in this district, will shortly be described in detail in one of the *Explanatory Memoirs* of the Geological Survey, now being prepared for publication. I shall not, therefore, further allude to it here, except to state that these ores are everywhere similar in character, being silicious brown hematites, varying in quality according to the proportion of silica, and thus passing into jaspery iron ore. They also follow, with more or less regularity, the stratification of the rocks in the neighbourhood.

'I shall now pass on to give some account of the iron ore at Red Hills, near Belturbet, which I have recently visited, and which lies in a district not yet examined by the officers of the Geological Survey.

'The ore here has been traced at intervals in a S.W. and N.E. direction, for a distance of about six miles, following the strike of the Silurian rocks, from Ballyhaise through Red Hills to the grounds of Scott's House, the residence of Mr. Madden. Whether it is perfectly continuous throughout this distance is uncertain, as the strata are frequently concealed by boulder clay; but in any case the quantity of ore must be very large; and if we suppose, as we have every right to do, that the ore follows the stratification of the rock inwards, below the surface, the quantity must be absolutely incalculable.

'At Red Hills, the property of the Rev. E. B. Whyte-Venables, the ore is now (1877) being vigorously worked by an English company, and is carted from the mine or quarry to a landing-stage on the Cavan and Clones Railway, from whence it is carried to Dundalk, and shipped to Cumberland, Lancashire, and North Wales. The works were commenced only in 1876, and already upwards of 5,000 tons have been shipped off.

'The hill on which the principal excavations are now in progress shows the following approximate section of the strata:—

1. *At the Top.*—Silicious hematite, sometimes passing into red and green jasper (only locally workable)	About 50 ft. in thickness.
2. *Best Ore.*—Dark fissile brown hematite, about 12 ft. in thickness	
3. *Inferior Quality.*—Silicious brown hematite, irregularly accumulated, passing into jaspery rock	
4. Reddish shales, of considerable thickness, sunk through in a pit for 30 ft.	65 ft.

'In appearance, the ore, when opened out, seems almost devoid of definite arrangement or structure; and it is only when it is in contact with beds of shale or grit that it can be observed to coincide approximately with the bedding of the rock. It, therefore, does not occur as a lode or vein, traversing the strata in a highly-inclined position, but rather in the form of lenticular beds of extreme irregularity. The ore itself is split up by innumerable planes of jointage or false-cleavage, traversing the mass in various directions.

'An analysis of the Red Hills ore, by Mr. John Cameron, F.C.S., of Askam-in-Furness, for the Red Hills Mining Company, shows that the ore is well suited for the manufacture of Bessemer steel, phosphorus and sulphur being entirely absent. The analysis was kindly presented to me by Mr. Whyte-Venables.—

'*Analysis of Red Hills Iron Ore.*

Peroxide of iron	57·57
" manganese	traces
Protoxide	6·20
Alumina	8·93
Carbonate of lime	0·50
Silica	22·80
Water of combination	3·00
Soluble matter	1·00
	100·00

Amount of metallic iron 40·30 per cent.'

Iron Ores, Japan. Iron is produced in Japan in larger quantities than any other mineral excepting coal; but although rich ore is found in many districts of the

country, it is very insufficiently worked; the difficulty of transport, there being no road in the mountainous parts where the mines are situated, rendering the cost so great, that the Government, to which most of the mines belong, seem disinclined to invest much in their exploration. However, some interesting experiments have recently been made in the province of Hitachi, at Nakakosha, where there is a bed of ironstone from 5 to 18 feet in thickness. The ore is very rich, and as it is situated near a navigable river, there is every hope that it may be worked to some advantage. An English engineer is employed in erecting furnaces on the spot, but the works are not completed, so the result is as yet uncertain. Another experiment is being made in opening some mines at Heigori, in Rikushiu, where a large quantity of magnetic ore has been found. Here the Government purpose laying down a tramway from the mines to the smelting works, a distance of 11 miles, and from there 2 miles farther to the coast, where the pig iron could be readily shipped to the various markets. The annual produce of these mines has not as yet exceeded 1,500 tons, but it is estimated that when the new works are completed the output will be very greatly increased.

Magnetic iron ore is the kind most commonly used in Japanese metallurgy, and is found in large quantities in Karima, Hoki, Satsuma, Idzumo, Wakasa, Twami, and Hiuga.

Specular iron ore is found in Hiuga and a few other places.

Brown hematite is found in Idzumo, Mutsu, Hiuga, Satsuma, Shinano, and Bizen.

Clay iron ore is very commonly found.

Stalactitic iron ore is rare.

Iron pyrites are very common, but this ore is rarely worked.

The total production in 1874 was 5,000 tons, since which there has been no return.

New South Wales, *Brown Hematite, Goethite.*—Very large and extensive irregular deposits and pockets of brown hematite occur at Wallerawang, Jamberoo, Nattai, Port Hacking, the Murrumbidgee, Mount Tallula, and many other places, such as between Mount Tomah and Mount King George. In fact, this mineral is one of the most widely diffused.

A specimen of brown hematite, from Wallerawang, yielded the following results on analysis:—

Water, hygroscopic	1·28
,, combined	12·04
Silica and insoluble matter	12·19
Sesquioxide of iron	73·00 = 51·2 per cent. metallic iron.
Phosphorus	·12
Sulphur	·06
Undetermined	·71
	100·00

Limonite is found in large stalactites formed by the ferruginous springs at Berrima, Nattai, and elsewhere, and the deposits of brown iron from these often contain beautiful impressions of leaves and other objects; also in botryoidal and mammillated forms.

Argillaceous Iron Ores.—Extensive deposits of clay band iron ores occur interbedded with the coal measures of New South Wales. These form an earthy variety of brown hematite; yet they are often very rich, and as they occur in immense quantities in close association with coal, they form a most valuable source of iron.

A specimen from Wallerawang yielded the following results:—

Water, hygroscopic	1·28
,, combined	3·54
Silica and insoluble matter	4·60
Sesquioxide of iron	80·00 = 56 per cent. metallic iron.
Phosphorus	·49
Sulphur	·11
Undetermined constituents	9·98
	100·00

Specimens from two other seams in the same locality yielded 40·28 and 53·31 per cent. of metallic iron respectively.

Similar clay bands occur at Jamberoo; in the Buttar Ranges, near to East Maitland; at Mount Wingen, and elsewhere.

Pisolitic Iron Ore.—Large superficial deposits of this and brecciated iron ore, red and brown, occur near Bungonia and Windellama Creek.

Red Hematite, Specular Iron Ore occurs in a coarse-grained granite at Summer's

Hill, near Bathurst, and at Mount Lambie; also at Bookham and Yass, with micaceous and massive red hematite; micaceous hematite also occurs at Pine Bone Creek with titaniferous iron.

Titaniferous Iron.—There are several different kinds of titaniferous iron, distinguished by their physical properties and by the amounts of titanic acid which they contain.

These are found usually with alluvial gold deposits about Ophir, Bathurst, Mudgee, Bingera, and at Uralla, in the diamond drifts. Large rolled masses occur at Uralla. Ilmenite, Menaccanite, nigrine, and iserine are said to occur with gold, garnets, and chrysolites in the Two-mile Flat Creek, Cudgegong River, and in the Lachlan with magnetite.

New Zealand, Otago.—Hematite of excellent quality, containing 94 to 96 per cent. of oxide of iron, is found near Maori Point, on the Shotover, where it is said to occur in a lode 6 feet thick. It is also found in the vicinity of Port Molyneux.

Clay iron ore exists near Tokomairiro and near Marunwhenua.

Titaniferous iron sand is found in considerable quantity at Port William, in Stewart Island.

Prussia.—*The Production of Iron Ore in* Prussia *in* 1872 *and* 1873.

Nature of Iron Ore worked	Quantities of Ore extracted	
	In 1873	In 1872
	Tonnes = 564 lb.	Tonnes = 564 lb.
Limonite	25,685	29,012
Brown hematite	1,674,658	1,661 660
Carbonate	742,901	771,466
Argillaceous	55,396	26,768
Red hematite	698,145	657,181
Magnetic ore	10.415	9,277
Oolitic ore	223,932	240,692
Oligiste iron	352	—
	3,555,005	3,671,367

Zeitschrift für das Berg-, Hütten-, und Salinen-Wesen im Preussischen Staate, 22nd vol. 1874.

Russia.—A letter from Michel Levitsky describes some recent discoveries of iron ores in Central Russia, and informs us of deposits of iron ores near the village of Krapivna, in the northern part of the Smolensk government, about 32 miles from the town of Bieloi and 30 miles from Michailovskaia station, on the railroad from Warsaw to Moscow. These ores occur in the Devonian basin of Western Russia and in the district of Bieloi. The upper bed, which is a brown hematite mixed with clay and sand, is at a depth of only 1 to 7 feet below the surface, the overlying soil being a reddish yellow clay. This bed of iron ore is from 20 to 30 inches in thickness, and in many parts is succeeded by another bed of similar ore from 7 to 16 inches in thickness. The chemical analyses made at Moscow and St. Petersburg of the iron ore taken indiscriminately show it to be a hydrated peroxide of iron with an admixture of sand and clay, and to contain from 29·7 to 35 per cent. of metallic iron. Similar ores are said to occur in more than twenty places, situated about 15 miles one from the other in this district.

The average annual production of iron ore in Russia is said to exceed 325,000 tons.

Spain.—La Felguera, in the Asturias, is the most important of the few ironworks existing in Spain. In the *Revista Minera* for February 1876 it appears that the number of workmen employed were as follows:—

Employed in the interior of the works	930
Extracting 342 tons of coal used daily	694
" 126 " iron ore smelted in the 24 hours .	126
" 63 " limestone used as flux daily . .	42
Employed at Gijon Pier	200
	1,992

The establishments are two, Felguera and Vega. The first and principal is situated in the valley of Langreo, and was erected in 1860. The works cover 47,300 square

mètres. There are 3 blast furnaces, provided with 3 blowing machines, 2 elevators, and 8 steam boilers. The forge contains 24 puddling furnaces, 3 steam hammers, 2 forge trains, 3 pairs of shears, 10 reheating furnaces, and 10 steam boilers. They have 36 coke ovens on the Belgian, and 36 on Arroll's system.

The Vega works contain one blast furnace only. The whole of the machinery of both these establishments is kept in motion by 39 steam engines, having a collective force of 850 horse-power. It is estimated that these ironworks can turn out annually 20,700 tons of pig iron and 14,000 tons of rolled wrought iron, including some 5,000 tons of rails.

In March 1876 King Alfonso visited the Goldames mines, belonging to the Bilbao Iron Ore Company, the result of which was that the export duty on the Bilbao ore was reduced from 2 reals, or 5d., per ton to half a real, or 1¼d. per ton. At this date there were more than 100,000 tons of iron ore ready at the mines. The quantity of iron ore exported to France in the first five months of 1876 was 55,397 tons, as compared with 39,800 tons shipped for France in 1875.

Iron Ore Imports into the Ports of the Tyne and Tees from Mediterranean Ports in 1876.

Ports from which shipped	Tyne	Tees
Bilbao	22,452	11,176
Cartagena	9,921	—
Palomares	15,138	1,417
Pormanelos	1,816	—
Aguilas, Almeria	4,788	—
Elba	3,943	5,107
Algiers, Oran, Camerela	3,431	—

Styria.—Recently (1876) a 'Mémoire sur la Situation de la Métallurgie du Fer en Styrie et en Carinthie,' by M. F. Gautier fils, has been published in the *Annales des Mines* (2nd and 3rd livraison de 1876). From that excellent paper the following information has been obtained:—

Iron Ores worked.

	Archduchy of Austria	Styria	Carinthia	Carniola	Tyrol	Salzburg	Total
	Tons *	Tons	Tons	Tons	Tons	Tons	Tons
1851	8,760	161,000	66,000	12,000	12,500	15,400	200,250
1861	9,900	193,800	100,800	17,500	13,000	11,000	352,500
1871	7,000	376,800	167,600	10,100	8,800	6,000	576,300

The diminution in the production of iron ore in all the districts except those of Styria and Carinthia is striking. It is stated by M. Gursner that between 1872 and 1874 the increase in the production of iron ore in those two countries has been still more rapid.

Sweden.—The total quantity of iron ore raised in Sweden in 1874. The latest authentic returns published was—

	Swedish cwt.	English tons
Output from 2,213 iron mines	21,692,998	903,875
Dredged from lake and bog ore	101,122	4,213
	21,794,120	908,058

In 1874 the mining authorities granted 2,659 concessions for newly discovered deposits of iron ore.

In the same year were granted 24 concessions for lake and bog ore.

Swedish Lapland contains some immense deposits of iron ore, which have hitherto remained unworked, on account of their inaccessible position. A survey of these deposits was made last summer by the Government, in consequence of a proposal to make a line of railway that would open up this mining field, and would extend from the Gulf of Bothnia to the Atlantic. The samples of ore collected have been analysed, and the following results obtained:—

* Of 1,000 kilos.

Gellivare is the best known of the iron mountains of Lapland. It has passed through many hands, and is now the property of an English merchant residing in Stockholm. The report says: 'This field, the most extensive in Sweden, and as large as all the other fields in Lapland put together, is not, properly speaking, an ore mountain, but a mountain with beds of ore occupying an area of 7,400,000 square feet, or $\frac{1}{25}$th of its surface. The ore is magnetite, often richly interspersed with apatite and hæmatite, for the most part coarsely grained, the latter as layers enclosed in the former, without any sharp boundary. The gangue is red gneiss. The iron found in these ores is generally considerable. Of 41 average samples, which have been collected and analysed, 26 showed, by the assay, upwards of 70 per cent. (one up to 74·3 per cent.), 13 between 60 and 70 per cent., and only 2 under 60 per cent. (the lowest 50·3 per cent.). Unfortunately the contents of phosphorus rise in most of them to a high percentage, 28 holding upwards of 0·1 per cent. (varying between 1·727 and 0·104 per cent., the average being 0·515 per cent.), 3 between 0·1 and 0·05 and 10 under 0·05 per cent. (the lowest 0·011). Although the hæmatite appears to contain much less apatite than the magnetic iron ore, it holds, however, as much phosphorus. The content of sulphur, on the contrary, is exceedingly small, 9 of the samples containing over 0·05 per cent. (the highest 0·18 per cent.), 20 contained 0·05 per cent. or under, and in 12 this impurity was found to be completely absent. The contents of manganese, which always increases the value of an ore, only amounts to 0·16 per cent. The content of titanic acid varies between 0·45 and 1·91 per cent. This ingredient is not detrimental to the iron, but causes certain metallurgical inconveniences. By sinking only 1 foot over the whole mountain, 925,000 tons of ore might be obtained, whence could be produced as much iron as is yearly worked at present in the whole of Sweden. Of this area, there are, however, only 1,074,000 sq. ft. so free of the phosphorus that they are adapted for the production of Bessemer steel; but, on the supposition that the same proportion holds good underground as on the surface, 134,000 tons of ore suitable for this purpose could be broken up by sinking 1 ft. It may be remarked, that though in the processes by which malleable iron is commonly manufactured in Sweden 0·01 of phosphorus is considered large, iron quite suitable for common purposes may be produced, by their method of puddling, and from much more impure ores. For some kinds of casting, ores containing phosphorus have a decided preference over others, not only on account of the fusibility of pig iron made from them, but also on account of its not rusting so readily as other kinds of pig.'

Kurunnavaara, another remarkable deposit, lies about sixteen English miles from Jukkasjarvi Church, and ten miles from Lorne River. It consists of a straight ridge of compact magnetic iron ore forming a bed in a porphyritic-elvan mixed here and there with hæmatite, which extends 14,000 ft., having a breadth of between 185 and 780 ft., and occupies an area of 3,526,000 sq. ft. The average samples brought from it show a content of pig iron of between 70 and 73·12 per cent. in 12, of between 65 and 70 per cent. in 13, and of less than 65 per cent. only in 3, the lowest giving 61·5 per cent. The content of phosphorus is large; 24 samples ranging between 0·305 and 2·302 per cent., the average being 1·396 per cent.; in the other 4, which are from the end-points of the bed of ore, 0·030 per cent. and 0·047 per cent. The content of sulphur amounts to 0·03 to 0·15 per cent.; of manganese to 0·15 per cent., and of titanic acid to 0·32, 0·60 per cent. The quantity of ore has been calculated at 54,442,000 tons in the summits of the ridge, 170,917,708 tons below these down to the level of the Lake Luossajarvi, and 440,000 tons for every foot sunk below that. Of ore of the best quality, on the supposition that it continues underground of the same purity as at the surface, 14,412,291 tons in the summits, and 42,237,000 tons from their base to the level of the lake.

Luossavaara, another deposit, lies to the north of the mountain just described, and was discovered at the same time. It is of a conical form, and the rock is for the most part covered with earth. The bed of ore extends 4,500 ft., the greatest breadth being 155 ft., and the area being 659,000 sq. ft. The iron contents in 5 of 8 average samples was 70–73 per cent., in the other 3, 67·4–69 per cent. The content of phosphorus was found to be very low, being in 2, 0·003 and 0·008 per cent., in other 2 under 0·02 per cent., in other 2 under 0·03 per cent., and only in the 2 remaining higher than 0·05 per cent. (0·037 and 0·082 per cent.); the content of sulphur ranges from 0·03 to 0·09 per cent.; the content of manganese amounts to 0·15 per cent., and of titanic acid to 0·91 and 1·00 per cent. The quantity of ore in this remarkable mountain is calculated at 27,000,000 tons down to the level of Luossajarvi Lake, and about 70,000 tons for every foot deeper; and thus, if to the ore in this mountain there were added that of the finest quality in Kurunnavaara, there might be a yearly production of 800,000 tons for a whole century without going below the surface of the lake.

Svappavaara is situated about twenty-five English miles to the south-east of

Loossavaara. Ore was first discovered there in 1654, and between that date and 1686 a large quantity of copper ore was raised. A mint was established there for a short time, at which copper money was coined; some of the sinkings reached a depth of 312 ft., but then the influx of water became so great that the mines had to be abandoned. The copper ore occurs partly in the form of true beds, and partly as later formations in the form of veins, &c. The iron ore, part hematite, part magnetic iron ore, rendered impure only exceptionally by a few particles of pyrites, forms the highest part of the mountain, and has a length of 2,100 ft., a breadth of 180–330 ft., and an area of 421,000 sq. ft. The six crucible assays show 64–69·5 per cent. of iron in the magnetic iron ore (3 samples), 50·5 and 68 per cent. in the hematite, and 72·3 per cent. in the hematite sand. The content of phosphorus is uncommonly great: in the 3 samples of magnetite 0·9–1·347 per cent., in the hematite 0·251 and 1·462 per cent., and in the hematite sand 0·129 per cent. The content of sulphur is pretty high: in 4 of the samples 0·15 per cent., in the others 0·06 and 0·07 per cent. The summit of the mountains contains, according to calculation, the large quantity of 6,533,540 tons. Sjangeli, a mountain situated on the Norwegian frontier about thirty English miles from the Atlantic, has been famed as containing rich copper ore, but in too limited a quantity to be worked profitably.

From these analyses and the calculations founded on them, it appears that the Lapland ores are very rich, and the supplies are almost inexhaustible, though for the most part they contain too much phosphorus to be suitable for the production of Bessemer metal. Of course only direct examination of samples from different depths can show whether the quality of the ore is the same underground as at the surface.

The proposed railway for opening up these ore fields would extend from the Gulf of Bothnia at Sveloa to the Ofoten Fiord in Norway, which is always open during the winter, and it is estimated that it would cost 950,000*l.*

Were this railway made, the ores would probably be transported to the Gulf of Bothnia, and they might be manufactured there at a cost of 56*s.* per ton (including 2*s.* 6*d.* per ton profit), for the cost of mining would be very low.—*Mining Journal*, July 16, 1876.

IRON ORES DEPHOSPHORISED *by* Jacobi's *Process at the* Kladno Iron-works, *Bohemia.*

'The problem of dephosphorising iron ores is one of great importance, as the most extensive deposits are nearly all contaminated with this impurity. Among deposits thus deteriorated, and producing, by ordinary modes of treatment, pig iron with from 1·5 to 2 per cent., or more, of phosphorus, are those of Cleveland, Luxemburg, Lothringen, Bavaria, Hanover, Bohemia, and many other districts.

'On the other hand, this phosphorus, which is a most injurious impurity in an iron ore, would be of great value to the agriculturist if it could be economically separated, and applied as a fertiliser to the soil. The quantity of phosphorus in the pig iron produced annually in Cleveland alone may be estimated at 30,000 tons, and its value to the farmer, if it could be separated in such a form as to be applicable as a manure, would not be less than 280,000*l.*

'Phosphorus in iron ore exists entirely in an oxidised form, as a phosphate of some one or more of the bases of the ore; nearly the whole of it in the ores of Bohemia, Cleveland, Luxemburg, &c., is combined with lime and alumina, not above a twentieth part, at most, being in combination with oxide of iron. That the phosphoric acid is not in the form of phosphate of iron may be proved by digesting the ore in a solution of sulphide of ammonium, a reagent which decomposes phosphate of iron, forming sulphide of iron and phosphate of ammonia, but does not attack the phosphates of alumina or of lime. The proportion in which the phosphoric acid is divided between the alumina and the lime may also be readily determined. The presence of phosphate of lime is to be expected, as the phosphorus existing in the ore is derived from the *débris* of fossils containing it; but phosphate of alumina appears to be also present in greater proportion than was supposed before the date of Herr Jacobi's experiments.

'Phosphate of iron is soluble only in the stronger acids, and even these do not attack it unless moderately concentrated. The phosphates of alumina and lime, on the other hand, though insoluble in water, dissolve readily not only in very dilute acids, but also in many saline solutions, such as those of common salt, chloride of magnesium, nitrate of soda, &c.; and even water charged with carbonic acid attacks them to some extent. Thus the removal of phosphorus from iron ores is relatively easy, when it is not contained in them as phosphate of iron.

'The mode of treatment adopted by Herr Jacobi at the Adalbert Hütte, Kladno, Bohemia, belonging to the Prager Eisenindustrie Gesellschaft, is as follows:—

'The ore, which occurs in massive beds resembling the deposits of Luxemburg and Lothringen, is broken into pieces of 3·5 to 7 cm. at most, and calcined in vertical

kilns. The calcined ore contains about 43 per cent. of iron and 1·5 per cent. of phosphorus. It is placed in large tanks, holding each 500 tons, and is treated for twenty-four hours with a solution of sulphurous acid, produced by burning iron pyrites in the same way as for making sulphuric acid, and condensing the fumes in water. The acid solution is then run off and is heated to 176° or 194° Fahr., in a coil of cast-iron pipes. The sulphurous acid is thus driven off, about 30 per cent. of the quantity originally used being recovered, and the liquid is then conducted into a settling tank, in which the phosphate of alumina that had been held in solution by the sulphurous acid deposits in the form of an impalpable white powder. Only a very small proportion of the phosphorus removed from the ore is, however, thus recovered, as during the treatment in the tanks a part of the sulphurous acid contained in the solution becomes oxidised to sulphuric acid, which is not driven off by the subsequent heating of the liquid, and thus retains by far the larger proportion of the phosphates in solution. The deposit from the settling tank consists mainly of phosphate of alumina ($3\,Al^2O^3,\ 2\,PO^5$), together with about 36 per cent. of water, and small quantities of silica and of sulphates of alumina and iron.

'The average composition of the ore before and after treatment is as follows:—

	Before. Per cent.	After. Per cent.
Iron	43	46
Alumina	14 to 18	6 to 8
Lime	4	1
Silica	14 to 16	20 to 22
Phosphorus	1·5	0·25

'The following table gives the percentage of phosphorus contained in the ore after different modes of treatment, and in the metal produced from it:—

	Ore	Pig Iron	Puddled Iron
Unwashed ore	1·1 to 1·2	1·7 to 2·1	0·8 to 0·9
Ore washed with a solution of sulphurous acid	0·2 to 0·3	0·5 to 0·6	0·15 to 0·2
Ore washed with water	0·5 to 0·6	1·0 to 1·1	—

'It will be observed that a sensible amount of phosphorus is removed by treatment with water. The explanation of this is, that the ore itself contains pyrites, producing, on calcination, sulphuric acid and sulphates, which, in the presence of water, dissolve a portion of the phosphates.

'The cost of treatment per ton of ore, exclusive of general charges, is as follows:—

	s.	d.
Iron pyrites, 275 lb., at 52s. 6d. a ton	6	5
Coal, labour, &c.	1	8
	8	1

Equivalent to 20s. to 25s. per ton of pig iron.

'No account is taken in this estimate of the phosphate of alumina recovered. So much, however, of this as is obtained is employed in the manufacture of alum, and of phosphate of lime for manure.

'The financial position of the PRAGER EISENINDUSTRIE GESELLSCHAFT, the disproportion between the cost of treatment and the results obtained, and the competition of the adjoining district of Styria, where the price of pure ores is extremely low, have prevented a really industrial development of the process, though the trials made of it have been on a comparatively large scale; and if any plan of the kind should come to be followed out generally at the Kladno works, it would probably be confined to the washing of the calcined ore in water, so as to make foundry iron of improved quality, without attempting to dephosphorise the ore more completely. Such calcination and washing is advantageous, independently of its effect in removing phosphorus, as it gets rid of much of the sulphur, and so admits of producing a softer and greyer pig iron.'—M. GAUTIER, *Mémoires de la Société des Ingénieurs Civils.*

IRON AND STEEL. (IRON, vol. ii. p. 918; STEEL, vol. iii. p. [illegible].) *The Blast Furnace.*—There has been for some years a feeling prevailing amongst ironmasters that as the capacity of a furnace, especially in height, was increased, so was the economy of production improved. Mr. I. LOWTHIAN BELL has opposed this view, and brought forward strong evidence in support of his opinions. M. L. GRUNER has

given some excellent suggestions in respect to the construction of blast furnaces in his work, *Etudes sur les Haut Fourneaux*. In this he says, after discussing all the conditions observed in working the furnaces under his charge:—

'1. That the production of large blast furnaces, above 200 cubic mètres in internal dimensions, does not increase in proportion to their capacity.

'2. That up to a certain limit, which varies with the state of the ore and of the fuel, it is advantageous to increase the height of blast furnaces; but beyond this limit there is no further advantage in augmenting either the height or the capacity.

'3. That the minimum consumption corresponds to a mean speed of the general descent of the charge, *i.e.* either an excess or a deficiency of the blast leads to an increased consumption. In both these cases there is a tendency to depart from the ideal mode of working.

'4. That the heat furnished by the hot blast replaces advantageously that furnished by direct combustion near the tuyeres, but that the relative economy nevertheless decreases in proportion to the rise of the temperature. Above 700° to 800° C., the real advantage becomes inconsiderable. The hot blast, by cooling the upper part of the furnace, promotes, then, the breaking up of the carbonic oxide, and in consequence secures an approach to the ideal of working.'

From Mr. Isaac Lowthian Bell's excellent paper, 'On the Economy of Fuel in the Blast Furnace for Smelting Iron,' we quote the following, which appears to us to meet the whole question:—

'Two great improvements in the smelting of iron have now been considered, viz. the use of heated air, and the increase of size in the furnace. In point of reputation the hot blast occupies by far the more important position; but it will be seen from what has preceded that in point of real merit, so far as economising fuel is concerned, Neilson's discovery is not entitled to this distinction, which is one it has acquired from priority of introduction, and from a supposed virtue believed to be the peculiar property of heated air.

'These observations are at present limited in their application to the stage to which this inquiry has been brought, which consists in having proved that, in the matter of fuel consumption, a 71-ft. cold-blast furnace performs as perfectly as one driven with heated air, having an altitude of 53 ft. The 53-ft. hot-blast furnace, it is true, turns out a larger make of iron than that blown with cold air (probably 200 tons per week against 120 tons), but on the other hand the latter, without any apparatus to maintain or fuel to expend for heating the air, is able to do its work as efficiently, in point of fuel consumed in the furnace, as the other, assisted by the more complicated appendage suggested by Neilson.

'It now remains to consider the prospect there is of constructing a furnace so large as to dispense altogether with the use of hot air, without a sacrifice of fuel used in the furnace itself; afterwards to examine the effect of uniting the benefit derived from a high temperature of blast with that obtained by enlarged capacity; and then to test the belief expressed by Mr. Siemens last May, that "the blast could not be made too hot for economical purposes, and that real progress in iron smelting must henceforth be looked for chiefly in that direction."[1]

'The first portion of this inquiry has been already answered in showing that 25½ cwt. of coke are capable of evolving 93,000 cwt. heat units, the estimated number of units required for producing a ton of pig iron from an ore yielding 40 per cent. of metal. Discarding hypothesis, foundry iron was actually obtained at Lilleshall with cold blast for 27½ cwt. of coke; and forge iron in 1834, according to Dufrénoy, was smelted in France with 25 cwt. before the use of hot air was suggested by Neilson.

'This reduction of 12½ cwt. of coke at Lilleshall was effected upon an ore only requiring, in a 53-ft. furnace, 40 cwt. of this combustible. Whether it would be possible to force the air conveniently through a column of material so high as to be able to produce a ton of pig iron from black-band with 25 to 27½ cwt. of coke with cold blast, is a question which would demand consideration. This doubt arises from the circumstance that this variety of iron stone, parting with its oxygen so slowly, consumed in a low furnace 60 cwt. of coke per ton of metal, and would therefore obviously demand a much larger addition to its capacity to bring its coefficients of fusion and reduction into harmony with each other, than an ore only taking 40 cwt. to smelt it under the same conditions as to temperature of blast.

'There remains to be considered—a furnace sufficiently large to enable the ascending gases to divest themselves of their sensible heat, and to become saturated with oxygen, both operations, it will be assumed, being effected to the extent permitted by the nature of the process. Suppose now into such a furnace, instead of cold air, the blast was admitted at a temperature of 485° C. (905° Fahr.), the same effect in point

[1] Vide Minutes of Proceedings, Inst. C.E. vol. xxxii. p. 344.

of increase of intensity would follow as happened when the blast was changed from cold to hot in the lesser furnace, and some of the extraordinary consequences supposed to be due to this additional intensity of heat in the hearth should manifest themselves, if the value of the hot blast were dependent thereon. Such, however, is not the fact; for the furnace, having now sufficient capacity to permit the two functions of fusion and reduction to proceed in point of time in unison with each other, instead of one heat-unit in the blast doing the work of three or four previously evolved by the fuel, each unit of heat thrown in with the air does no more duty than one unit produced by the combustion of coke in the inside of the furnace.

'There is no doubt, with combustible matter of the same commercial value, it would be much simpler to obtain the necessary heat by the direct action of the blast on the fuel in the hearth of the furnace. Inasmuch, however, as the air is now heated by the escaping gases or by coal of little worth, there is, in spite of the law just enunciated, a notable advantage in the source of heat rendered available by NEILSON's invention. The question, therefore, which presents itself is the extent to which it can be substituted for that generated by the more expensive description of fuel used in the furnace itself.[1]

2370

'The chemical laws already alluded to which regulate the power of carbonic oxide to deoxidise an ore of iron in presence of a gas having a contrary tendency, such as carbonic acid, impose a limit to the substitution of mere heat for heat accompanied by the carbonic oxide, the generation of which served as its source. The quantity of carbonic acid due to the reduction and carbon-impregnation of an ore of iron is that represented by 6·58 cwt. of carbon for each ton of metal. In the diagrams (*figs.* 2370, 2371) it was assumed that, if the volume of carbonic acid materially exceeded 45 volumes to 100 volumes of the lower oxide of carbon, reduction was nearly suspended. In practice, however, it may be regarded as difficult, if not impossible, to saturate the gases with oxygen to an extent even to obtain this relation between the two oxides of carbon, owing to the slowness of the operation. As a rule, when the gases contain for 100 volumes of carbonic oxide 40 volumes of carbonic acid, it may be assumed that the process approaches the extreme limit to which, in treating the ironstone of Cleveland, it can be carried. When the gases have absorbed a quantity of oxygen sufficient to establish the relations just mentioned, the weight of carbon consumed will be that represented by 21 to 21½ cwt. of good Durham coke. When this quantity of such coke is burnt to the condition of oxides in the proportions mentioned, the heat evolved is not sufficient to discharge the demand made upon it in smelting a ton of iron from Cleveland stone; and the deficiency is exactly that represented by the quantity of heat usually contained in the blast at any well-appointed furnace on the banks of the Tees. In other words, if 25½ cwt. of coke, burnt under favourable conditions, can smelt a ton of iron with cold air, 4 cwt. of such coke can be saved if into the furnace a quantity of heat can be introduced with the blast representing the 4 cwt. in question.

2371

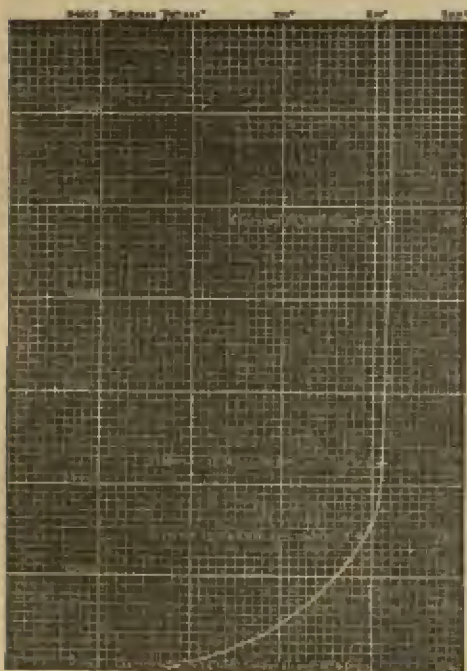
'Supposing, however, that, instead of being content with the blast being heated just

[1] Conveying heat into the furnace by means of the blast possesses great advantages, enabling the smelter to pour in a supply where it is most required, without waiting for any change in the burden of coke and ironstone which come down into the hearth.

enough to afford an economy of 4 cwt., which would be about 485° C. (905° Fahr.) Mr. Siemens' recommendation is adopted, of raising its temperature say to 800° C. (1,472° Fahr.). This addition to the heat resources of the furnace will immediately be felt all over its contents; and as soon as it reaches the zone of reduction, where the temperature is such that the carbonic acid therein generated is inert on carbon, this condition of things experiences a complete change, and the super-heated carbonic acid now dissolves coke, which is productive of loss, both from the cooling effect of the reaction and from the actual diminution of fuel arriving for combustion at the tuyeres.

'Mr. Bell has proved this by repeated analyses, and he has invariably found, that just as any excessive quantity of heat was injected into the furnace with the air it received, so did there disappear a quantity of carbonic acid from the gases, corresponding exactly with the needlessly high temperature conferred upon the blast.

2372



'The solvent power, as it were, of the gases over oxygen having reached its limit when 30 per cent. of the reducing carbonic oxide has passed into the higher state of oxidation, is a barrier to further economy, because reduction then practically ceases. If, however, reference is made to the table of heat appropriation formerly quoted, it will be perceived there is a loss of nearly one-tenth of that evolved by the sensible heat carried off in the escaping gases. Appreciable as this is, it is less by one-half from a furnace of 12,000 cubic feet than it was from one of 6,000 cubic feet.

'In the year 1869 Mr. I. L. Bell published a diagram (*fig.* 2372), containing the results of repeated observation on this question, by means of which it was demonstrated that a furnace 80 feet high, and containing 12,000 cubic feet, emitted the gases as cool as one twice this size (*figs.* 2370, 2371). In this diagram the temperatures of the escaping gases as they leave furnaces of very different dimensions are shown by means of a curve. Since that time larger and larger dimensions have been adopted in the North of England, until a capacity of 41,000 cubic feet has been reached without, in Mr. Bell's opinion, a commensurate advantage having been obtained. The maximum cooling and oxygen saturation of the gases are secured in a furnace of 16,000 cubic feet, and certainly the increase of make has not kept pace with the increase of size, as may be seen from the following statement:—

Furnace of cubic feet . . .		6,000	12,000	16,000	26,000	41,000[1]
Weekly make . . .	Tons	220	260	350	400	550
Weekly make per 1,000 cubic feet	"	37	23	22	16	13

'Mr. Bramwell agrees with Mr. Bell that there was a limit below which it was useless to hope to reduce the temperatures of the escaping gases, but his conclusion rested on entirely different grounds from those assigned by Mr. Bell. The language made use of by Mr. Bramwell was as follows: "The incoming materials in a given

[1] The effect of a large furnace of 41,000 cubic feet, producing less in proportion than one of 16,000 cubic feet, is that the charge for interest on outlay is about as 100 to 66 in favour of the latter.

time remained a constant quantity in relation to that of the outgoing gases, so that when a height was attained sufficient to give time for the incoming material to take up from the outgoing gases the whole of the heat which that incoming material was competent to absorb, any increase in time must be entirely useless."'—*Minutes of Proceedings of the Institute of Civil Engineers.*

The United States blast furnace, *fig.* 2373, was designed for the NORTH JERSEY IRON COMPANY by Messrs. WEIMER, of Lebanon, Pa., U.S., and Mr. JOHN BIRKINBINE, of Philadelphia. It is an example of a structure showing evidence of considerable permanence, and it appears to have been erected with considerable economy. It is stated that the walls are made as light as possible, and every provision is made for keeping the furnace cool about the bosh walls and crucible. Instead of the ordinary masonry pillars or iron columns, housings are used, which extend up to and support a hollow mantel just below the bosh or greatest diameter. The hollow mantle is so formed as to be of great strength, and at the same time keep the bosh cool. The heavy iron housings which support the mantel and superincumbent masonry are cast so as to support also the bosh walls, crucible walls, water, blast and spray pipes, the spaces between them giving ready access to tuyeres, &c. Slots are cast in the faces next to the walls of the housings, to accommodate T-heads on square iron rods, so as to bind the bosh walls with a minimum amount of iron; the bands, having to extend in this case only from one housing to another instead of around the stack, can be much lighter, and expose more of the masonry to the cooling effect of exposure. The spray pipe just below the mantel can also be used to cool the bosh walls. An iron casing encloses the crucible walls, leaving space for sand, through which water is permitted to percolate for cooling effect. The walls above the mantel follow the general slope of the in-walls, and are secured by iron bands, varying in size, and fastened by double clevices. The top of the stack is surrounded with an iron casing, having openings for the down-takes to the hot blasts and boilers. The tunnel-head is fitted with the ordinary bell and hopper, covered by a patent furnace charger shown in the above figure. This consists of an inverted cone placed over the hopper, in which there are openings, through which the ore, flux, and fuel are charged. These openings—there are three in the apparatus as illustrated—are closed by sliding doors secured by hinges to a revolving ring on top of the cone. The hinges are placed as a precaution against accident from explosions of gases while the doors are closed.

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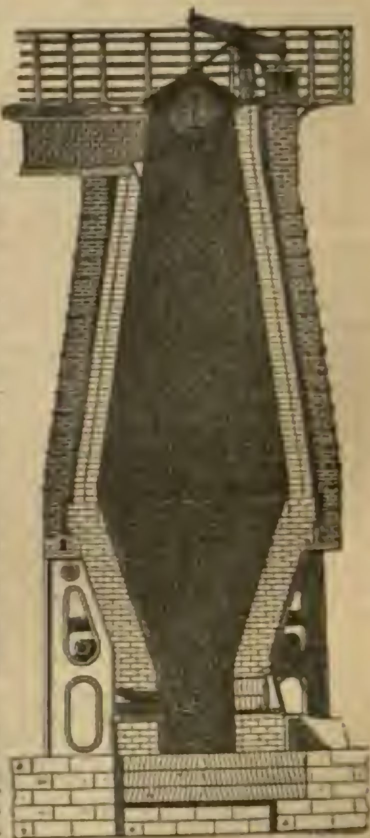


Near the tunnel-head is secured a casting, acting as a fulcrum to a wrought-iron beam, and enclosing two cylinders, one vertical and one horizontal. The cylinders are fitted with the necessary valve chests, valves, pistons, &c., and can be arranged to be operated by steam, hydraulic, or pneumatic power. Upon one end of the beam the bell is hung, and the piston rod of the vertical engine engages with the other end. A weight box in the beam permits of the proper balancing of it, and the height of the bell can be regulated by a screw and nut on the rods supporting it. The piston rod of the horizontal cylinder engages with a connected rod secured to the revolving ring carrying the sliding doors. Ordinarily, in dropping the charge with the bell and hopper, a large volume of gas escapes, not only from the throat of the furnace, but also from the down-takes, hot-blast stoves, and boilers, necessarily occa-

sioning intermittent temperature. To obviate this trouble and secure the regular operation of the furnace this charging apparatus is designed. Its operation is as follows: The furnace being in operation, and the bell closed against the hopper—both of which are turned off to make a joint—the doors are open, and the charges of ore, flux, and fuel are dumped into the hopper, but cannot reach the furnace, on account of the bell being closed. When the charge is ready to be dropped, steam is admitted into the horizontal cylinder, and the movement of its piston closes the sliding doors. Steam is then admitted into the vertical cylinder, and the bell is lowered, the charge passing into the furnace; after which the bell is raised and doors opened by reverse action in the respective cylinders. The entire apparatus is under the absolute control of the attendant, and the operation of each cylinder is independent of the other, and is regulated by levers.

It is obvious that in dropping the charge the only gas which escapes is the little which could be contained in the space between the bell and cone of the charger; the flow to the boiler and hot-blast stoves is therefore uniform, and the operation of the furnace is as a consequence under more direct control.—*The American Polytechnic Review.*

Furnace Lining.—M. E. P. Audouin, of Paris, has patented a composition which he states to be more effectual than any known material in resisting the action of oxide of iron. This material is oxide of chromium, which is capable of resisting the highest temperatures employed in furnaces such as the Siemens furnace, and furnaces heated by dead oils, and is also said to be proof against the action of oxide of iron at the highest degrees of heat. The inventor claims that there is no danger of the oxide being reduced under the ordinary conditions of working; and, moreover, that the presence of a small quantity of chromium will not affect the quality of the iron. The oxide of chromium may also be utilised in the manufacture of fireproof blocks to be exposed to the action of furnace cinder and scoria, but it is admitted that the advantages are less marked, as by the action of potash, soda, and lime, chromates are eventually found.

Lignite in Blast Furnaces.—The following statement respecting the use of raw lignite in the blast furnace possesses much interest. It appears that in the blast furnaces of Styria 50 per cent. of raw lignite have been for some time used with the coke in the furnaces:—

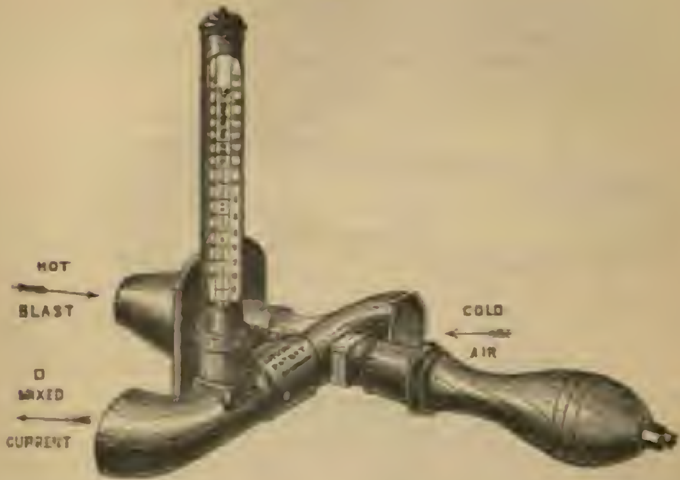
In 1874 the furnaces of the Styrian Eisenindustrie Company were daily producing 800 cwt. dark grey Bessemer pig from ores containing 46 to 50 per cent. iron. Per cwt. of iron the consumption of coke was 150 lb., and of limestone 30 lb., the temperature of blast being about 400° Cent. The coke burden was 30 cwt., carrying 40 to 42 cwt. ore. The furnace in which the experiment with the lignite was made possessed six tuyeres of 3 in. diameter, and the pressure of blast was about 2½ lb. In April, 1875, the manager, after a continuance of experiments for several months, had been able to replace 50 per cent. of the coke by raw lignite. It is essential to the success of this charge, that an increased pressure and temperature of hot blast should be secured and maintained, and the ore be in pieces and not in dust.

Hot Blast Pyrometer.—At a recent exhibition Mr. Joseph Casartelli, of Manchester, exhibited a pyrometer (*fig.* 2374) which is thus described by the inventor, Mr. Hobson:—

'In this instrument the aim is to tone down the temperature of the blast by an admixture of a constant proportion of cold atmospheric air, so that the highest temperatures likely to have to be recorded are brought within the range of a good mercurial thermometer. The hot blast is introduced in the form of a jet, which, by suitable arrangements, is made to induce a stream of atmospheric air, and the mixed stream then passes on and impinges on the bulb of a thermometer. The size of the jet, and the area for the induction of cold air, are fixed and unalterable, hence it is assumed that the proportion of hot blast to cold air is always constant; for, if the pressure of the blast increases or diminishes, it necessarily causes a corresponding increase or decrease in the quantity of air induced. This seems sufficiently clear, but in order to remove all doubts it has been proved by experiment that this instrument gives the same reading as Siemens' copper ball pyrometer, whether the pressure of the blast be 4½ lb. or 2 lb. per square inch. This was tried in the following manner: First, a trial with Siemens', then with this instrument; in both cases the blast being at 4½ lb. Immediately after the blast was lowered to 2 lb. pressure, and the instrument tried again. The result was that they agreed at 4½ lb. and they agreed at 2 lb., thus clearly proving that variation does not affect the constancy of the ratio. On similar grounds there is no reason to suspect that variations in temperature, with a constant pressure, alters the ratio to any practical extent, for although a low temperature means a greater discharge by weight from the jet, still a greater discharge means a greater induction and *vice versâ*. In graduating the instrument no attempt is made by abstruse and possibly ill-founded calculations to determine direct the exact

ratio of hot blast to cold air. Having taken suitable precautions, so that the highest temperature to be tested cannot damage the thermometer, the hot blast is first tested

2374



by a standard pyrometer, say SIEMENS' copper ball instrument, which, for example, registers say 1,000°. The new pyrometer is immediately tried in the same blast, and when the mercury has ceased to rise the indication of the thermometer is recorded, say 362°. After deducting 70° (= atmospheric temperature) from each, and dividing the lesser by the greater $\frac{292}{930} = \cdot 314°$, the rise of the thermometer per actual degree in the blast above the atmospheric temperature is obtained, and from this any other point in the scale is readily calculated. From this it is clear that it is quite immaterial what particular ratio is adopted, providing that ratio is unalterable, and it need not be the same in different instruments. In fact, although the ratio of hot blast to cold air can now be readily calculated thus:—

$$\left.\begin{array}{l} W = \text{Atmospheric temperature} \\ T = \text{Temperature of mixture by thermometer} \\ X = \text{Relative weight of cold air (hot blast} = 1) \\ Z = \text{Actual temperature of hot blast} \end{array}\right\} \text{then } X = \frac{Z - T}{T - W} = 2 \cdot 18,$$

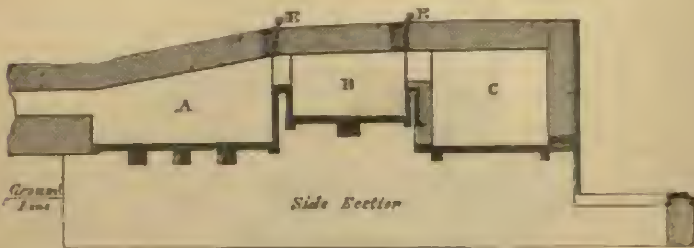
it is not even necessary to know what the ratio is. In manufacturing these instruments, however, it is clearly advisable to make the ratio the same in all instruments, for if not, every instrument would have to be separately tested by a standard. On the other hand, if sufficient uniformity can be attained in their manufacture to secure absolute identity in ratio, then it becomes necessary to test only the first one, and mark all the rest to the same scale. By practical trials it has been found easy to accomplish this. As the atmospheric temperature is liable to variation, the inlet for induced air is so placed as to draw its supply from a region as far as possible removed from the influence of radiation and conduction. By so doing, and taking the mean variation temperature in calculating the scale, and by using a thermometer of as high a range as possible, so as to require less of the diluting and variable medium, sufficient truth for practical purposes is attained without having to resort to a second thermometer to test the atmospheric temperature; which would not only make a complicated instrument, but would necessitate the use of the above formula for every observation. As it is, by submitting to a maximum error of 22° corresponding to an atmospheric variation of 10° above and below the mean, a simple and sufficiently accurate instrument is obtained, which can be used by any workman and without any arithmetical process.'

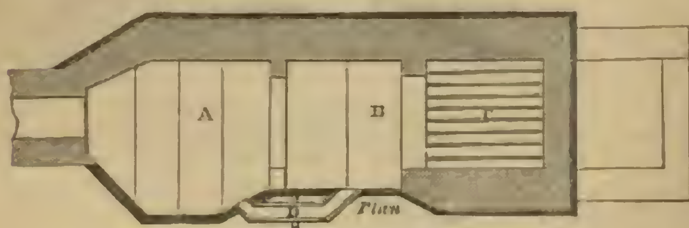
Puddling. Mr. MIDDLETON, of Leeds, has introduced a new puddling furnace in which he melts the pigs in a separate chamber, by which he thinks he economises fuel and that the iron is to some extent purified.

Figs. 2375 and 2376 illustrate the system. The furnace is similar to the old style

of furnace, excepting that between the puddling chamber, A, and the firegrate, C, is fixed a melting chamber, B, where the pig-metal is brought into a molten state. The heat first enters the melting chamber, B, and converts the pig into a fluid state, which is then run into the puddling chamber, A, by means of a channel or spout, D. While the molten iron is being worked, the melting chamber, B, is again charged with pig, which when melted passes into the puddling chamber, A, as before, and so on in succession, thereby keeping the puddling and heating chambers, A and B, continuously at work. After the fire is first fed, the above process consumes the whole of the smoke;

2375





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and the heat generated in the melting chamber, B (which in the old process escaped up the chimney) is utilised in the puddling chamber, A. When the metal is required to be refined, a blast, E, is introduced into the melting and puddling chambers in such a position as to produce the required heat upon the metal.

CADDOCK'S *Puddling Furnace*.—In 1867 a patent was granted for a puddling furnace, and recently (1876) SAMUEL CADDOCK, Pembroke, Maine, U.S., has patented a series of improvements therein.

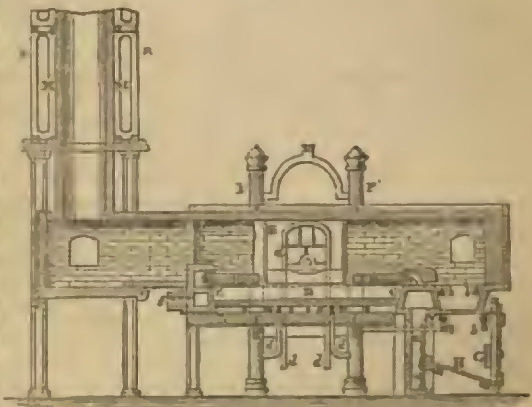
Fig. 2375 is a longitudinal section of the improved puddling furnace, and *fig.* 2376 is a cross section of the same.

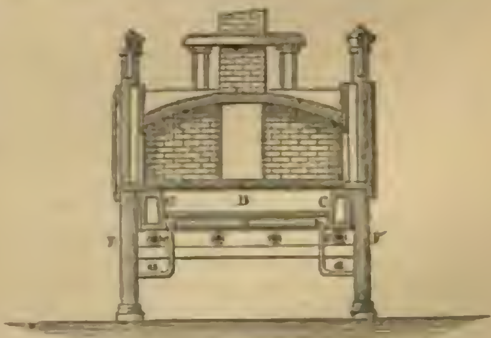
The puddling furnace may be of any desired size, and constructed of the usual materials. Surrounding that part, B, of the furnace where the iron is puddled is a metallic chill, C. This chill may be circular, hexagonal, or of any other desired shape, and it is hollow or formed with a continuous channel passing within it. On the top of chill, C, and surrounding it, are affixed, in any desirable way, water-pipes, D, and to the under side of the bed-plate, *e*, are secured water-pipes, *a*. Surrounding the inner framework of mouths, E, of the furnace are water-pipes, *d*. Passing along the upper edge of the furnace, immediately above the grate-bars, is a water-pipe, *b*. This pipe passes along one edge, returns and passes along the other edge, passes down and immediately below one of the blast-pipes, and returns, passing beneath the other of said blast-pipes. Supporting the sides of the furnace, at or near the doors of the same, are columns or standards, F F'. Through the column, F, is admitted the water which supplies the several pipes hereinbefore described, and through the column, F', it is discharged. Supporting the furnace proper on its under side are a series of tubular bearers, *e e*. These bearers may connect at their front ends in any desired manner with the blast-pipe, and at their rear ends with a blast-box, or in any suitable way convey the blast to the furnace fires. Beneath the ordinary grate, G, is placed a supplementary grate, H. This supplementary grate may or may not be connected to the blast, as desired. The inner doors, through which the iron is stirred or puddled,

are formed on their inner side or face, so that sections of fire-brick may be inserted therein and held in position by a dove-tailed flange formed on the inner edge of the door.

The puddling furnace being constructed substantially, as above described, its operation is as follows:—The fire having been kindled on the grate, G, the iron undergoing the process of puddling is placed in the bed, B, and a blast being forced through the orifice, *f*, which opens into the channel of the chill, c, it is conducted through and around said channel into a blast-box or otherwise, and thence through suitable perforated outlet-pipes to the furnace fire. It will be readily seen, therefore, that this means of supplying the blast is efficacious in two respects. It constantly circulates a current of cool air, which reduces the temperature of the chill and preserves it from burning, and by the time the air has circulated it has become heated sufficiently to form, as it were, a hot blast for the furnace fire, and thereby effects a large saving in fuel. As an additional economy, there is below the furnace or grate, G, an additional or supplemental furnace or grate, H, for the purpose not only of heating the air and other gases that pass up from the ash-pit, but also allowing it to catch the partially consumed coals that fall from the upper furnace and fully complete their combustion. In puddling furnaces heretofore constructed, the water channels around the mouths of the furnace doors and beneath the puddling pit, and other places throughout the furnace, have been cast with the several parts, so that when these channels were burned up, or the plates were fractured, it became necessary to supply new plates with new water channels, at considerable expense, besides interrupting the operation of the furnace. By CADDOCK's improvements the inner edges of the openings are attached in the furnace pipes, *d d*. These pipes may be secured to the furnace mouths by lugs or clamps, or in any suitable manner, so as to keep them in position, one end of each pipe connecting with the columns, F, and the other opening into the columns, F′, the supply of water being through the columns, F, which act as mains, and the outlets being through the standards, F′, as before described.

2377





2378

Secured to the bed-plate, c, are water-pipes, *a*. These pipes are not cast into or with the bed-plate in the ordinary way, but they are attached to the bed-plate by lugs and bolts, or in any way so that, if the plate burns out or becomes fractured or warped, the water-pipes remain undisturbed, and can be readily affixed to a new plate

as soon as it is placed in position. These pipes receive their supply of water from the columns, F, and they discharge it into the columns, F'.

Surrounding the upper edge of the chill, C, is a water-pipe or pipes, D. This may be one continuous pipe or may be sections, and they are secured to the upper surface of the chill by brackets or lugs, or in any way so that, when the chill burns out or is fractured, the water-pipes remain intact, and are readily adjusted to the new chill when fitted. This pipe receives its supply of water from the standards, F, and discharges it into the standards, F', in the same manner as do the other pipes.

Passing from one of the columns, F, is a pipe, *b*, which enters into the fire-box immediately above the grate-bars, passes along one edge of the same, returns and passes along the other edge, goes down and passes into the supplementary fire-box, passes along below and in contact with one of the blast-pipes, returns and passes below the other blast-pipe, and discharges into the standard or column, F', keeping up a constant circulation of cool water, preserving the walls of the fire-box and the blast-pipes from intense heat. This pipe is not cast on to or with any part of the furnace or blast-pipes, but is secured thereto, as are the other water-pipes, so that they may be replaced, if necessary, without disturbing their contiguous parts, or, in case the contiguous parts are burned out or fractured, the pipes remain intact, and can be fitted to the new parts when placed in position.

If, for any reason, it is thought desirable to discontinue the blast from the chill, or if more blast is required than can be admitted through the chill, the blast may be admitted through the tubular bearers, *e*, and thence conducted into a blast-box, or otherwise to the fires. This blast may be introduced into the bearers through hollow uprights, *g*, or, as before stated, it may be introduced in any way thought advisable.

Instead of lining the inner face of the inner or protecting doors with fire-brick in the ordinary manner, depending upon cement and iron straps to hold the fire-brick material in position, the door is cast or otherwise formed with a flange, having formed in its inner face an inclined recess. The fire-bricks are moulded with their edges at an angle that will fit into this inclined recess, so that when they are in position the last brick acting as a key will hold them firmly in position. The advantages of this method of lining the doors are that any part of the brickwork that has been burned, warped, or otherwise destroyed, may with great facility be removed and new sections replaced without disturbing the whole lining, and also, the brickwork being confined by an equal pressure throughout, it is not so likely to warp and budge by the action of the heat as it would otherwise do.

As is well known, the bit or orifice through which the puddling irons are introduced, is rapidly worn away by the friction of the irons against them, in which case the door is generally discarded for a new one. By this improvement there is affixed to the front of the door a movable wrought-iron bit, so that as the bit becomes worn a new one may be replaced at once without disturbing the door. This bit may be attached by slides or lugs and bolts, or in any way.

It is necessary to cover the outer surface of the brick forming the chimney stack with the ordinary red brick, so that the fire-brick may be preserved from the weather and kept in position. To obviate the necessity of this construction, and at the same time to bind the stack with a uniform pressure, so that it will not warp from unequal expansion or contraction, the four angles of the stacks are enclosed with angle irons, M. These irons may be of cast or wrought iron, and are preferably made in sections and bolted together. Surrounding these irons, and supporting them and the stack, is a framework, N, composed of uprights, n n n. This framework is cast with or otherwise connected to the angle irons, M, and forms part of them. The lower part of the framework sets into a base, and the upper part of it is bolted to a cap. This cap being flush, or nearly so, with the upper end of the stack, the cap not only tends to stiffen the whole framework, but it acts as a shield to prevent the carbonic and other noxious gases from enveloping the end of the stack and disintegrating the brick. Under the stack, or what is technically known as the 'stove,' is fitted a door which opens downward for the purpose of dropping the accumulated ashes, &c. As an additional means of holding the fire-brick to their inner surfaces, the doors are cast with a concave inner surface, and the bricks formed with corresponding convex surfaces, so that they may be held in place by the fitting curved surfaces together with the angular flange before described.—*The Iron Age*, New York.

Puddling Slag.—Dr. KOLLMANN, of Oberhausen, has examined with much care specimens of slag and iron taken during the operation of puddling at the Königshutte works in Upper Silesia.

The specimens of slag were taken from the furnace in a ladle lined with lime. The following are the conditions of ten samples:—

1. Slag taken from the hearth at 10.43 a.m., after thorough cleansing.
2. Slag taken at 11.17, after complete fusion of the charge.

3. Slag taken at 11.27 from the upper surface of the bath.
4. Slag taken at 11.35.
5. Slag taken at 11.38.
6. Slag taken at 11.46, at the beginning of the refining.
7. Slag taken at 12.14, before the end of the refining.
8. Slag taken at 12.20, at the time of coming to nature of the first puddled ball.
9. Sample of slag taken under the hammer during the shingling of the first puddled ball.
10. Slag taken at 12.42, five minutes after the removal of the last bloom.

Each of these specimens was most carefully analysed, giving the following results:—

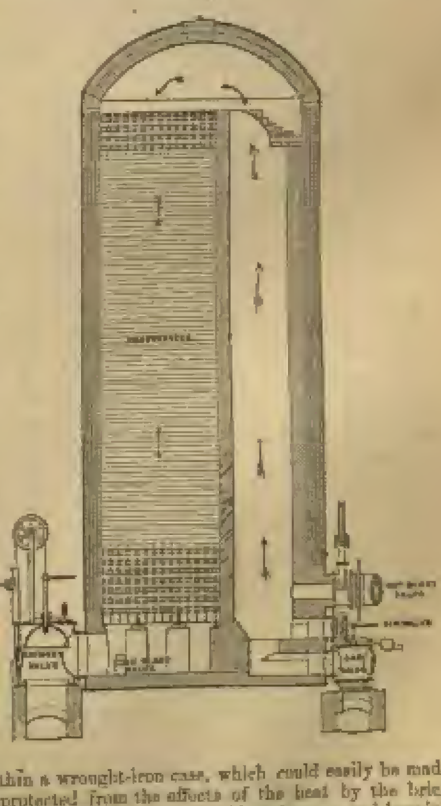
	1	2	3	4	5	6	7	8	9	10
Silica	15·93	17·12	20·80	23·16	20·27	19·08	21·91	16·41	10·00	17·00
Protoxide of iron	24·18	59·06	51·01	52·43	47·46	51·68	48·76	48·04	61·02	61·33
Peroxide of iron	22·21	9·81	7·72	6·24	9·04	11·48	12·56	13·48	19·09	17·84
Oxide of manganese	0·34	9·35	12·48	12·51	10·10	11·08	12·87	14·40	6·16	0·84
Alumina	0·32	0·56	0·43	0·49	0·80	0·27	0·50	0·34	0·53	0·42
Lime	0·70	0·09	0·80	0·53	0·61	0·59	0·43	0·62	0·61	0·58
Phosphoric acid	2·30	2·40	4·30	4·22	8·48	4·26	5·10	4·17	1·75	2·98
Sulphuric acid	traces	—	—	—	—	—	—	—	—	—
Iron	60·77	5[illegible]·80	47·67	45·63	50·73	48·30	45·02	46·79	52·67	52·14

Slag is a silicate containing in solution more or less protoxide or peroxide of iron. On a microscopical examination of slag finely pulverised and thrown into water, transparent particles can be seen flecked by dark and very visible spots. Basic slag contains more dark flecks than other slags. These dark spots in slag are protoxide and peroxide of iron, whilst silicate of iron gives spots of considerable brilliancy.

It appears easy to explain the favourable effect of the manganese in the pig on the products of refining. The manganese hinders the breaking up of the oxides of iron in the silicate of iron, and consequently retards the formation of the refinery slag.—'The Chemistry of Puddling,' *Annales Industrielles.*

Hot Blast, Cowper's.—Since the great improvement effected by the late Mr. Neilson by the introduction of hot blast of about 600° Fahr., there has perhaps been no greater improvement in the smelting of iron than that produced by the invention of Mr. E. A. Cowper, of blast heated in regenerative hot-blast stoves to 1,400° or 1,600° Fahr., the 'regenerator' being on the same principle as those introduced by Mr. Siemens.

2370

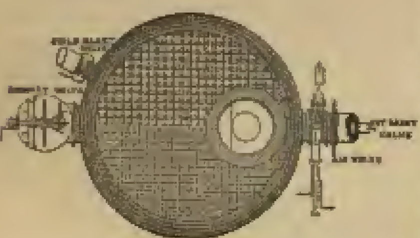


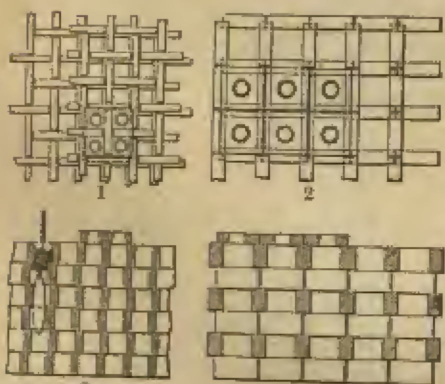
In 1857 Mr. Cowper first proposed to construct a fire-brick regenerative hot-blast stove, by enclosing a 'regenerator' composed of fire-brick within a wrought-iron case, which could easily be made perfectly air-tight, and could be protected from the effects of the heat by the brick lining inside it, then by taking waste gas from the top of a blast furnace, and burning

it in the stove, the brickwork was heated up, not equally throughout, but to the highest temperature at the top, where the flame first acted, and then as the products of combustion passed down through the passages in the regenerator, the products became cooled, and the bricks became heated; then after this had gone on for some two or three hours, the valves were changed, and the cold blast went in at the bottom and gradually took up heat from the very surfaces of the bricks that had been previously heated up by the products of combustion, and thus when the blast passed away to the furnace, it was heated up to a very high degree; and now, owing to various improvements that have been introduced for perfectly distributing the air throughout the regenerator, and in the proportionate height and diameter of the regenerator, &c., the blast can easily be heated to 1,500° Fahr., and be kept very regular at that temperature.

The stoves are worked in pairs alternately, so that whilst one is being heated, another may be heating the blast, and one is put on before the other is taken off, so that there is no cessation in the blast. Sometimes two or three stoves are made to blow two furnaces. At Messrs. SCHNEIDER'S, where the 'COWPER stoves' are adopted in preference to all others, there are 25 stoves, variously arranged for the numerous furnaces, there being in one case nine in a row for four furnaces; at Ebbw Vale there are four stoves for two furnaces, making 800 tons of best Bessemer pig per week; at Landore there are three stoves for two furnaces, also at Ormesby there are thirteen stoves in a row; and in France, Germany, and Switzerland they are likewise disposed in various ways to suit the situation, size of furnaces, &c. They are made of all sizes, from 15 ft. diameter up to 30 ft. diameter, but 10 ft. diameter to 26 ft. is about the commonest size.

2380





1 2 3 4

Fig. 2379 exhibits a vertical section through one stove, the gas valve, B, and air valve, C, are supposed to be open, and the flames passing up to the top, as shown by the arrows, through the circular shaft, D, and then descending through the holes in the covering tiles, F, and down through the passages in the regenerator, E, and out by the chimney valve, G. Then when the stove is heated up, the cold-blast valve, H, and hot-blast valve, I, are opened, and the blast passes up through the stove and down through the circular shaft, D, and hot-blast valve, I, to the blast furnace; the air, gas, and chimney valves of course being shut.

Fig. 2380 exhibits a sectional plan of the stove, with the valves, circular shaft, D, regenerator, E, with half of the covering tiles, F, removed, to show the construction of the regenerator itself. *Figs.* 1, 2, 3, and 4 show two methods of constructing the regenerator; and in *fig.* 3 the brush occasionally used for cleaning out is shown.

At the time when these stoves were first introduced, the ordinary temperature of hot blast from cast-iron pipe stoves never exceeded 750° Fahr.; but when it was proved that 1,200° Fahr. and 1,300° Fahr. blast from the 'Cowper stoves' produced greatly improved economy, many ironmasters pushed on their pipe stoves to produce a higher temperature, and although many were burnt down in the attempt, after sundry small improvements a temperature of 900° or a little over is now obtained by some parties with manifest advantage, though the economy and increased 'make' of iron, resulting from blast of 1,400° and 1,500° Fahr. from the 'Cowper stoves' is

still far in advance. Thus at one works where 28¼ and 29½ cwt. of coke used to be employed per ton of iron made, the consumption was at once reduced to 20¾ to 21½ cwt. per ton, and has since been brought down as low as 18¾ cwt. per ton of best Bessemer pig.

These stoves have been extensively adopted, and in every case greatly increase the 'make' from a furnace, besides giving great economy in fuel, and their use is largely extending.

CROSSLEY'S *Hot-Blast Stove.*—The object of this invention is to combine the advantages of the high temperature stove patented by COWPER and by WHITWELL (vol. ii p. 961) with those of the ordinary and cheaper cast-iron stoves.

The stove is so constructed that the gases—which, in the ordinary cast-iron stove, necessarily escape at a very high temperature, and in many cases in the actual process of combustion, thus causing an immense waste of heat, and consequently of fuel—are made to pass into an upper chamber above the ordinary stove, and there

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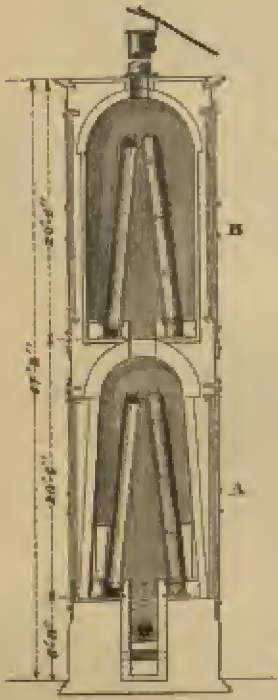

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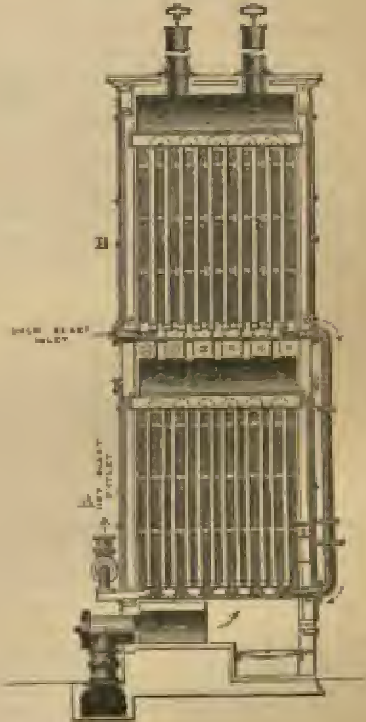

utilised for the preliminary heating of the blast. The waste gases from this chamber may again be passed into another chamber above, and there utilised in the same manner, thus abstracting practically the whole of the available heat; but for ordinary purposes this is not necessary.

The engravings show the stove arrangement, which consist of (*fig.* 2381 A) a chamber in which ordinary cast-iron heating pipes are arranged in any of the approved modes. Into this chamber the gas or other fuel may be admitted, and used in the ordinary manner. The method of combustion shown in the wood-cut has been found to work most satisfactorily. The openings for the escape of the heated products of combustion into the upper chamber much facilitate the proper distribution of heat in this chamber. *Fig.* 2381 B, a second or upper chamber into which the heated gases from the lower chamber escape through the opening indicated by arrows. In this chamber, as in the lower one, a series of cast-iron pipes are arranged in a similar manner; but

they may be fewer in number, and of a less thickness of metal, not having the same intense heat to withstand. The number which have been adopted at Askam are 12 in the lower and 10 in the upper chamber, and the thickness ¾" for the upper and 1¼" for the lower pipes. These heating pipes are shown in plan in *figs.* 2383 and 2384.

The blast is first conveyed through the upper series of pipes, and there heated by the escaping gases from the lower chamber to a temperature of about 500° Fahr. (260° C.), which is evidently clear gain over the ordinary single chamber system. The blast thus heated is then conveyed through ordinary cast-iron pipes, which should be covered with some non-conducting composition, or enclosed in a brick chamber, that the blast may retain the heat already acquired into the heating pipes of the lower chamber, where it is further heated to the temperature required for the blast furnace. This temperature may be the same as that ordinarily obtained from cast-iron stoves, in which case it will be of a more uniform character, and obtained with a less heating of the pipes, and consequently with less wear and tear, and at a saving of nearly 60 per cent. in gas or other fuel, or it may be at a temperature of 1,150° Fahr. (621° C), which is 200° Fahr. (93½° C.) above the temperature safely obtainable in the ordinary form of cast-iron stove, and may be secured without any higher temperature of the heating pipes than that required for the former temperature in the old form of stove.

It may be remarked that in case of accident the pipes can be removed from this with quite as much ease as from the old form of stove, but being more under control, the pipes are less liable to damage, and therefore do not require changing so frequently.

The advantages claimed for the stove are a saving of 40 per cent. of fuel used in heating the blast, a higher temperature than that now obtained, a uniform temperature, economy of fuel in the furnace, and thorough command over the temperature of the blast. The power of the stove is so great—due to the draught caused by its increased height, and also to the extent of the heating surface—as to be found to give such control over the temperature of the blast, that it may be kept constantly at the

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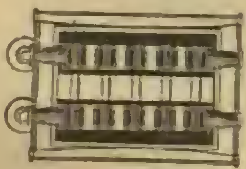

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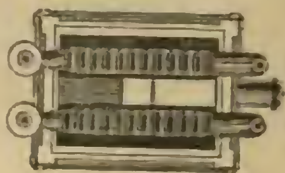

same temperature notwithstanding disturbance in the weather or accident at the furnace, which interfere with the quality or quantity of the gas. The stove has been at work for eighteen months, and has given the most satisfactory results.

Tuyere, Lloyd's *Patent Safety*. See article Iron, vol. ii. p. 947.

The patentee claims—and it would appear he fairly does so—that there is perfect freedom from any risk of tuyere explosions where these tuyeres are used, the tuyere being kept at a low temperature by the circulation of water, as shown in *figs.* 2385 and 2386, which indicate the entire construction of this particular tuyere.

There can be no leakage of water into the furnace.

Any overheating of the tuyere casing, through displacement of the spray pipe or defective water supply, can be at once detected, and in most cases remedied before the tuyere is injured.

If a tuyere is worn out or burned through, there need be no haste in removing it, and the blast need not be stopped purposely until a convenient opportunity occurs.

With good water supply these tuyeres are more durable than any other kind.

With defective water supply, or impure water, these tuyeres are at least as durable as any other kind, and are free from the dangers consequent on leakage, resulting from partial stoppage of water supply, where other tuyeres are used.

The cost of repair or renewal of these tuyeres is very small. The tuyere casings are very durable. The spray pipes are not exposed to any wear, and will last for years without renewal.

The fact that leakage into the furnace as well as explosion is impossible where these tuyeres are properly placed, is not always understood until the tuyeres have been tried, and it can be very readily proved in practice. Supposing that from stoppage of water supply (which must cause any tuyere to heat and burn) the nose end of one of the tuyeres were entirely burnt off. This would be an extreme case, and

can scarcely ever happen, yet the spray is so arranged that the inward pressure of blast from the furnace forcing its way back through the open space will at once blow

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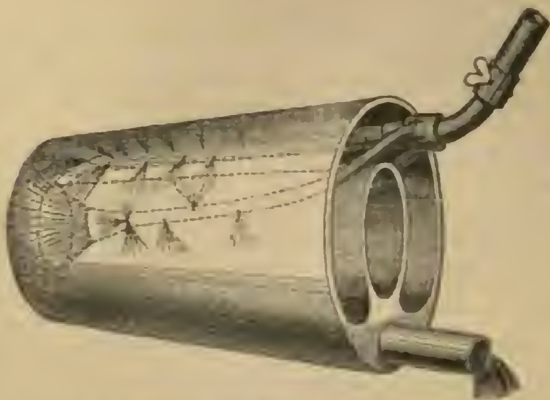
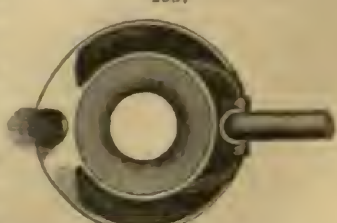


any spray or water that might otherwise fall into the furnace, back, simply wetting the tuyere lume, and causing no harm or danger. In the old system, either of coils or

2386

water jacketed tuyeres, where a hole, however small, is once made by burning or wearing out a tuyere, the water must leak into the furnace, and has no other means of escape. This causes some risk of explosion, but though the danger may often be small where coiled tuyeres are used, it is always great where water jacketed tuyeres are used, and there is no safety even with coils. But apart from this question of danger, the result of water leaking into a furnace invariably loses heat and very often causes such derangement of the working that it takes days to set it right. Two instances are known where furnaces have been entirely ruined from this cause, and had to be blown out, even though the leakage did not result in any explosion. Another point which is found important in practice is that very often a deficiency or stoppage of the water supply is seen before the tuyere is at all damaged; the tuyere being open at the back, such

2387



a circumstance is at once apparent. Tuyeres of this construction frequently last for months together where in former times the tuyeres were being renewed every few days.

Spray pipes are generally used as shown in the engraving, but perforated coils or bent pipes are also employed. All that is required is a sufficient number of small jets of water playing on different parts of the tuyere casing to keep it constantly wet and cool. It is seldom necessary to alter the existing water supply at furnaces adopting these tuyeres, and as a rule the waste water goes away not more than 10° hotter than the feed water. This varies much according to circumstances, but no difference is found in practice as to the amount of heat absorbed by the water, which is scarcely worth notice. If there is any difference on this point the advantage is on the side of the LLOYD tuyere.

Spiegeleisen.—Dr. ROSSITER RAYMOND, of New York, brought the following notice before the American Institute of Mining Engineers in 1876. It is so suggestive, that we give it entire:—

'I desire to call the attention of the Institute to an interesting experiment, which may turn out to be an indication of a valuable improvement in the manufacture of steel. As the members are aware, the addition of ordinary spiegeleisen, in the open hearth or BESSEMER converter, to a bath of decarbonised iron, has a twofold object—the recarbonisation of the bath to a desired degree, and the remedy of the red-shortness otherwise found to be inevitable in the final product. This red-shortness is ascribed to the presence of oxide of iron in the molten metal; and it is supposed that the manganese of the spiegeleisen, uniting with the oxygen of such oxide, carries it into the slag. At the same time there is a small percentage of the manganese usually left in the cast steel, probably to the improvement of its quality. Whatever be the true explanation, the effect of the manganese is acknowledged to be not only beneficial, but necessary. But the use of spiegeleisen containing high percentages of carbon limits the quality that can be introduced, because the carbon must be limited if soft steel is desired. This inconvenience becomes so serious as to prevent the use of ordinary spiegeleisen in the manufacture of steel containing more than, say two-tenths per cent. of phosphorus; since the quality of the steel can be made tolerable only by reducing its contents of carbon in proportion as the phosphorus is increased. The necessity of adding manganese, without adding carbon in excess, has led to the employment of ferro-manganese instead of spiegeleisen; and the only difficulty now remaining is the high cost of the ferro-manganese.

'Some months ago, while engaged with Dr. T. M. DROWN upon some literary labours relative to the metallurgy of iron and steel, I received from him the suggestion that the process of "annealing," employed in the manufacture of malleable castings, might be employed in the decarbonisation of spiegeleisen, so as to produce a manganiferous iron containing little carbon. In pursuance of this suggestion I requested a member of the Institute, Mr. F. J. SLADE, of the NEW JERSEY STEEL AND IRON COMPANY, to make an experiment, principally for the purpose of testing whether the oxidising agent employed in annealing would not remove manganese as well as carbon, and also to ascertain the rate and degree of the reaction.

'Broken pieces of German spiegeleisen, about 3 inches in diameter, were packed in scale from the rolling mill, in an iron box of about 1 cub. ft. capacity, and this box was placed on the back part of the hearth of a SIEMENS furnace, used as a heating furnace auxiliary to the melting furnace of the MARTIN process, at the works of the NEW JERSEY STEEL AND IRON COMPANY, at Trenton. In this position the box was exposed continuously for three weeks to a cherry-red temperature, after which it was removed, and the contents were examined. The interior of the pieces of spiegeleisen was apparently unchanged; but the outside, to the depth of about one-eighth of an inch, had been altered in texture and appearance. This exterior layer is no longer brittle, but exceedingly tough, so that it is extremely difficult to break it. By hammering a piece of this spiegeleisen the whole interior may be shattered, while the outside layer is simply battered, not broken.

'The following analyses made by Mr. J. BLODGET BRITTON show the chemical changes that accompanied this physical alteration:—

	I. Ordinary Spiegeleisen	II. Annealed Spiegeleisen
Phosphorus	·079	·055
Manganese	11·636	10·678
Carbon	3·016	0·429

'According to these analyses there has been a slight diminution in manganese and phosphorus, and a large reduction in the amount of carbon. It is evident that the annealed spiegeleisen can be used where the other cannot, in the manufacture of mild

steels. The advantage of this treatment, if it should prove economically practicable, would be still greater in the employment of the extra manganiferous spiegeleisen, such as is now produced from the blast furnaces in West Cumberland, England, and by the SOCIÉTÉ ANONYME DES HAUTS-FOURNEAUX at Marseilles, France.

'The following analysis shows the high percentage of manganese in the *spiegeleisen extra manganésé* of the latter company: a percentage, by the way, which they claim they can increase still further:—

Manganese	24·40
Silicon	0·43
Sulphur	0·060
Phosphorus	0·010
Carbon between 4 and 5 per cent.	

'If such a spiegeleisen, costing at New York, say $85 currency, per ton, could be decarbonised by the comparatively cheap process of annealing, it would be a profitable substitute for ferro-manganese at the present high cost of the latter.

'In carrying out such a plan in practice it would be necessary to have the spiegeleisen granulated or cast in thin plates, so that when surrounded with scale or ore, and heated, it might be annealed throughout.'

Fused Spiegeleisen instead of Ferro-manganese.—Instead of the ferro-manganese, Dr. RAYMOND recommends the use of fused spiegeleisen in the BESSEMER process.

He ignites spiegeleisen, rich in manganese, in an iron box for some time, in order to diminish the carbon, and to use the product for the preparation of soft steel. The following analyses show the effect of long heating:—

	a[1] Not fused	b Fused	c Not fused	d Fused	e Not fused	f Fused
Carbon . . .	3·016	0·499	3·430	0·100	3·45	0·106
Silicon . . .	—	—	0·445	0·449	0·555	0·614
Manganese . . .	11,636	10·698	0·629	0·525	0·585	0·575
Sulphur . . .	—	—	0·059	0·083	0·105	0·162
Phosphorus . . .	0·079	0·055	0·315	0·315	0·290	0·295

M. A. GRENIER has long been desirous of fixing the terms of a good definition of steel. As far back as 1869 he proposed to reserve this name for all *malleable siderurgical products obtained in a state of fusion*, reserving the term 'iron' for every malleable product which has not undergone fusion. From this definition it follows that the ancient steels, with the exception of cast steel, can be regarded merely as irons, more or less carburetted and steely. Cast steel, as well as the new metals bearing the names of BESSEMER, SIEMENS, MARTIN, &c., are the only true steels having the characteristic of being obtained in a liquid state, and run into homogeneous and compact blocks or ingots. Homogeneity and compactness, natural consequences of the liquid state, are the two characteristics of these metals, and belong to steel only. It is well known that masses of crude iron result merely from the juxtaposition of grains of iron at a comparatively low temperature, amidst a slag more or less liquid. By the processes of shingling and rolling the greater part of the impurities are squeezed out of this metallic sponge, and the particles of iron are brought sufficiently near to each other to be more or less perfectly welded together. Thus a rough, crude outline of iron is obtained, the primitive form in which iron is met with in commerce, and which is very different from that of crude steel. The latter, obtained at an extremely high temperature, is composed of small drops of iron, more or less completely carburetted, entirely exempt from slag, and forming when cool a homogeneous and compact block or ingot. It is the high temperature attained which impresses a peculiar character on the new metals. In fact, no other means is so effectual for expelling slag and rendering a metallic mass homogeneous. In practice the distinctions just pointed out cause the difference of the uses to which iron and steel are put. If the manufacturer requires a metal capable of resisting wear and tear, iron will not be selected. Mere juxtaposition of particles implies want of compactness, and probability of exfoliation and roughness of surface. This is the case with rails, especially at stations, inclines, and crossings, and with all articles exposed to great friction. If, again, a metal is required capable of bearing shocks and prolonged vibration, steel, if the respective tenacity is equal, is still superior to iron. The want of compactness of the latter

[1] *a* and *b*, spiegeleisen; *c* and *d*, *e* and *f*, ordinary pig iron.

Analyses of Spiegeleisen by EDWARD RILEY.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Iron	86·229	86·712	86·007	83·777	81·111	80·581	79·056	76·001	74·002	74·080	74·749	73·850	72·770	71·000	69·181
Manganese	8·984	8·448	9·850	11·789	13·089	14·770	15·048	18·218	19·400	19·768	20·518	20·423	22·000	23·090	26·072
Carbon	4·170	4·071	4·240	4·638	4·643	4·161	4·010	4·763	4·068	4·402	4·600	4·683	4·808	5·133	5·033
Silicon	·945	·620	·218	·041	·470	·066	·420	·376	1·640	·894	·637	·668	·476	·089	·162
Sulphur	·100	·030	·041	·010	nil	trace	·091	traces	·019	·037	·017	·032	nil	·010	nil
Phosphorus	·107	·083	·008	·064	·212	·368	·088	·059	·283	·083	·117	·064	·072	·008	·080
Copper	·494	·109	trace	·018	·090	trace	·043	traces	—	trace		—	·024	—	traces
	100·244	100·465	100·261	100·247	100·011	99·970	100·712	99·763	100·211	100·186	100·497	99·918	100·716	100·040	100·095
Total of elements other than iron and manganese	4·869	5·994	4·858	4·088	5·911	4·634	5·100	5·187	6·209	5·419	5·374	5·007	5·380	5·757	5·280

Mean of Fourteen Analyses, omitting No. 9, 5·30

Analyses of Carinthian Spiegeleisen by the KRANISCHE IRON COMPANY, of Laibach, *April* 1, 1876.

	1	2	3	4	5	6	7	8
Iron	78·01	73·50	68·71	63·27	59·00	53·39	49·17	43·83
Manganese	15·41	20·47	25·10	30·81	34·00	40·28	45·62	47·08
Carbon	5·20	4·00	4·47	4·08	4·80	4·00	4·80	5·73
Silicon	·72	·00	·69	·70	·65	·88	·91	1·08
Sulphur	·04	·03	·03	·03	·03	·09	·02	—
Phosphorus	·33	·23	·30	·28	·30	·29	·35	·23
Copper	—	—	—	—	—	—	—	—
Aluminium	·02	—	·01	·01	·01	·01	—	·03
Calcium	·30	·09	·07	·05	·08	·06	·06	·01
Arsenic	—	—	—	—	—	—	—	—
	99·83	99·82	99·06	99·90	99·98	99·81	99·63	99·79
Carbon (E. R.)	4·364 —	— —	— —	4·042 —	4·780 —	4·473 4·483	5·005 —	4·297 4·384

	I.	II.	Mean.
Carbon per cent. in ferro-manganese, 73 per cent. manganese	6·394	6·255	6·268

Analyses of Manganiferous Iron Ores.

	Portuguese					Locality not known	Carthagena			Southern Germany	Russian					Italian
	1	2	3	4	4a	5	6	7	8	9	10	11	12	13	14	15
Silica	8·25	3·70	8·15	4·25	3·88	14·90	6·22	6·99	7·97	10·60	1·50	2·40	3·50	5·90	1·52	—
Alumina	4·25	8·95	4·75	3·65	4·05	6·68	·11	·93	1·14	3·58	2·44	2·92	trace	2·08	1·25	—
Iron peroxide	22·75	23·47	45·55	23·65	23·40	12·81	45·54	36·74	39·97	35·91	·43	3·57	4·18	51·12	43·73	—
Manganese peroxide	50·70	47·10	30·88	51·73	51·73	31·77	29·62	33·81	35·80	7·02	65·21	71·46	86·20	30·51	23·57	—
Manganese protoxide	3·64	5·14	—	4·25	3·81	18·24	4·75	4·66	4·26	30·42	8·26	1·21	2·32	2·56	2·97	—
Lime carbonate	—	—	—	—	—	—	3·00	—	1·00	—	—	—	—	—	—	—
Lime	—	—	—	trace	trace	3·64	—	4·30	—	·57	trace	4·00	—	—	19·84	—
Lime sulphate	—	—	—	—	—	—	·30	—	—	—	—	—	—	—	—	—
Magnesia	trace	trace	trace	trace	trace	·70	·41	·71	·21	·42	trace	·51	traces	·40	·56	—
Baryta	—	—	—	—	—	—	—	1·09	—	—	14·87	—	—	—	—	1·09
Baryta carbonate	1·69	1·09	·34	·68	·68	1·14	—	—	·52	·44	—	—	—	—	—	—
Baryta sulphate	—	—	—	—	—	—	—	—	—	—	·34	—	—	—	—	—
Carbonic acid	—	—	—	—	—	—	—	3·42	traces	—	·39	—	—	—	—	—
Phosphoric acid	·57	·93	·55	1·45	1·45	2·30	·22	·04	·18	·33	·76	·18	·16	—	·14	—
Nickel and cobalt	—	—	—	—	—	—	—	—	—	—	·67	1·10	—	—	—	—
Sulphuric acid	—	—	—	—	—	trace	—	—	—	—	—	·04	—	—	—	—
Potash and soda	3·20	3·20	not determined			3·94	—	—	—	—	—	—	—	—	·47	—
Combined water	4·05	5·94	6·79	5·72	5·48	4·87	6·16	8·19	8·90	9·73	4·27	7·60	2·15	6·08	3·99	—
Moisture	1·77	1·16	1·01	1·58	1·68	3·81	2·07	—	—	1·20	1·52	4·96	1·02	1·97	1·45	2·53
Zinc oxide	—	—	—	—	—	—	1·92	·64	·68	—	—	—	—	—	—	·77
	101·85	100·73	98·92	96·99	96·15	100·00	100·92	101·42	100·83	100·22	100·86	100·01	99·53	100·62	99·49	—
Iron per cent.	15·93	16·43	31·89	16·56	16·54	9·97	31·88	23·72	27·98	25·14	·30	2·49	2·92	35·78	30·61	31·10
Manganese per cent.	34·87	34·93	19·52	36.01	35·65	30·33	22·40	24·98	25·93	21·90	47·62	46·11	56·29	21·27	17·20	19·30

	I.	II.	III.	IV.
Three cargoes of ore, in which zinc was specially determined, gave zinc oxide, per cent.	·68	·68	·44	2·10

involves the beginnings of fissures, which go on increasing till the article is fractured. There are multitudes of purposes for which the homogeneity of steel renders it preferable to iron, in spite of the difference of price. It must not, however, be supposed that steel is destined to supplant iron, especially as the new methods of mechanical puddling will place the latter in an improved position, bringing it a step nearer towards the homogeneity and compactness which are characteristic of cast steel.

At present siderurgical industry yields two series of products, identical in chemical composition, but differing in the manner in which they are obtained. The first is the scale of irons, commencing with common iron in its different states, passing then to granular iron of different qualities. Next, steely iron or puddled steel, often so rich in carbon as to admit of being tempered. Sometimes even it is scarcely malleable like Styrian steel. This is a species of refined cast metal, obtained in furnaces fed with wood, and so far freed from carbon that a single balling in the furnace renders it capable of being shingled, though with difficulty, and then drawn into steel wire of the first quality. At the top of this scale we must also place the cementation irons or steels, which are only irons highly carburetted by the immediate contact of carbon.

The second series forms the scale of steels. It is parallel to the foregoing, and each of its members is analogous to a member of the iron scale. It begins with extra soft steel, which welds like iron, and does not take a temper. Next follows soft steel, corresponding to granular iron and semi-soft steel, representing puddled steel. Lastly comes a hard steel, corresponding to the cementation irons or steels, and to Styrian steel. This final number of the scale welds badly and tempers readily. The following table shows the percentage of carbon for both series:—

Percentage of Carbon.

0—0·15	0·15—0·45	0·45—0·55	0·55—1·5
Series of Irons.			
Common irons	Granular irons	Steely irons, or puddled steel	Cementation iron or steels; Styrian steels
Series of Steels.			
Extra soft steel	Soft steel	Semi-soft steel	Hard steel

Mr. Edward Riley read a paper, *On the Estimation of Manganese in Spiegeleisen, and of Manganese and Iron in Manganiferous Iron Ores*, before the Iron and Steel Institute, in March 1877. From that paper the preceding tables are extracted (see pages 468, 469).

Steel, Bessemer. The following account of an improved Bessemer plant is from a paper read by Mr. John B. Pearse, of Philadelphia, before the meeting of the American Institute of Mining Engineers, at Cleveland, U.S., 1875. The whole works or plant has been divided into three parts. 1. The division in which the metals for conversion are melted. 2. The division in which the metals are converted into steel and cast into ingots, or the converting department. 3. The engine and boiler department, which supplies the hydraulic power required to move the machinery, and which furnishes the blast used for converting the crude metal into steel. The several departments have usually been so constructed as to be separate from each other, and so as to be practically separate buildings, separated by division walls extending to the roof.

'The pig iron is melted in cupolas, and is run into ladles mounted on heavy scales fitted to weigh about 16 tons, and placed at the height of from 14 to 16 ft. above a horizontal line drawn through the trunnions of the converting vessels. These ladles are usually placed 25 to 30 ft. behind the converting vessels, and are connected with the latter by spouts or runners, down which the melted metal runs. The spiegeleisen used for recarbonising is melted in air furnaces or cupolas in the cupola department; similar runners, usually connected with the ladle runners, conduct the melted spiegeleisen into the converting vessels. All these runners pass through a division wall by means of arched openings, and are usually from 35 to 50 ft. in length. In the Cambria Bessemer Works this division wall between the cupola and converting divisions has been omitted, but the general design is otherwise the same.

'In the converting department the converting vessels, two in number, stand up with their mouths towards the cupola department. They occupy, with their chimneys, a central position every way, being directly on each side of a line drawn across the cupola and converting departments, and through the centre of each department, and are almost centrally between the two departments. The converting vessels are so

placed that the flame, gas, smoke, and matter thrown out from the vessel during conversion are directed towards the cupolas and ladles. To protect the latter a large chimney is built for each vessel in the division wall. The matter thrown out from the vessel is thus projected against the back of the chimney where it adheres.

'The operation of converting the crude metal into steel is completed, with the aid of one ladle crane, and three lifting or ingot cranes. The ladle crane has an arm sufficiently long and strong to support a ladle weighing about 12 tons, when full of steel, at a distance of 15 ft. to 18 ft. from the centre of the crane post. The ladle crane carries the ladle around under the converting vessels, and then over the tops of a number of moulds, previously arranged in a circle. The lifting cranes are designed to lift from 5 to 8 tons each, and to cover a circle of about 30 ft. in diameter round the post of each crane. Two of these lifting cranes are arranged to swing just over the convertors, while the third is so placed that its circle just meets the circles described by the other crane jibs. All these cranes are moved vertically by water power, but all other motions are given by hand.

'The converting vessels are fitted with a tuyere box, which carries the refractory bottom lining of the vessel, and also the tuyeres, through which the blast passes on its way up into the melted metal in the vessel. This tuyere box is usually of large size and great weight, weighing over half a ton, without the refractory bottom or the tuyeres. A railroad track is laid under each vessel from the drying ovens, so far under the vessel that the centre of the car may come vertically under the centre of the vessel. The tuyere box, previously prepared with its bottom and tuyeres, is placed on this car, run under the vessel, and is lifted into position by a strong hydraulic lift, which rises beneath it, and lifts it so high that it may be keyed or bolted on to the vessel in its proper place.

'The buildings containing the boilers, engine, and pumps are usually placed along one side of the converting department, and most commonly at that opposite the side on which the cupola department stands.

'The cupola department must be made of great height, so that the cupolas and ladles may be sufficiently far above the converting vessels to secure a steep inclination of the runners down which the melted pig iron and spiegeleisen flow into the vessels. All the metal and fuel for melting must be lifted to a great height, thus necessitating heavy hoist arrangements and large expenditure of power. The cranes, being fixed in regard to location, have but one set of functions; none of the lifting cranes could take the place of the ladle crane, should that break down; nor if the lifting crane that serves the steel ladles should be injured, could either of the others replace it. The weight of the tuyere box and refractory bottom is so great that it necessitates special arrangements to handle them, and each converting vessel requires a separate and distinct set of these arrangements, as above described.

'The plan or design of the plant usually adopted is a dual one, that is, if a line be drawn between the converting vessels, and carried each way through the buildings, there will be one vessel, one drying oven, one ladle for molten iron, two cupolas for melting iron, and, in most plants, one air furnace or cupola for melting spiegeleisen, on each side of the line. This line also passes through the centres of the ladle crane and one lifting crane, and has one lifting crane on each side. Each of these sides is, with the exception of the ladle crane and the one lifting crane, which are common to both sides, complete in itself, and, in case of necessity, could be worked without the other side; but the two sides are destined to be worked together, and all the rest of the machinery of the plant is subservient to both in common.

'The second principal feature of the design heretofore used is that they are constructed round a central point. The vessels are the centre, and the whole plant is so arranged that the molten iron, spiegeleisen, scrap iron, and refractory materials are all brought to them in various ways, and the steel is delivered from them by means of the steel ladles swung round the circular pit. Around this pit, on one side of which these vessels stand, is conducted the whole work of conversion. In melting pig iron the product is easily carried away down the runners without further trouble, but, in the case of steel, we have ingot moulds and ladles, many of which are needed immediately round the pit. We have there, further, the drying ovens for vessel bottoms, not so much needed now, it is true; but the bottoms are still made up in the immediate vicinity of the vessels. But in front of one oven, as usually arranged, the steel ladles stand, and the moulds in front of the other. The steel ladles, after use, discharge their slag and scull under their crane, at one side of the pit, while the hot moulds are distributed round the other two cranes. The central position of the steel converting details is thus disadvantageous, for the heat arising from the hot moulds and glowing ingots greatly inconveniences the men. Besides this the inward movement of the material brought into the centre interferes with the removal of the

débris, and the *débris* itself of such operations is also more or less in the way of the operations.

'From the above descriptions it is evident that the design of the BESSEMER plant usually employed is of such a nature that any increase of capacity must take place by the union of two converting vessels and their necessary appurtenances. It would be far too expensive to build for one vessel the parts usually accessory to both vessels in common.

'The object of my improvements is chiefly to diminish the relative cost of plant per ton of steel, and the amount of the original total cost of erection, to reduce the cost of repairs by simplifying the apparatus employed, and also to arrange each part of the BESSEMER plant, and the whole design of the combination of the several individual parts, so that each separate division may be reached from the outside of the building, or for a space equivalent to the outside.

'With this object I unwind, as it were, the whole circumference of the pit, bring the cupolas down, and get my operations in a longitudinal line, instead of in a number of radial lines converging to a common centre. The iron comes in at one end, and goes out as steel at the other end. For these purposes I so arrange the converting plant that the whole of the machinery, including blowing engines, pumps, boilers, and all other necessary parts, may be placed under a roof of moderate span intended to be nothing but a shed made fireproof. The only raised floors employed are the platforms required to charge and work the cupolas, the highest of these platforms not being more than 18 ft. or 19 ft. above the ground, and all of them in one corner of the building. The cupolas stand on the ground, and the molten pig is tapped out of them into an ordinary foundry ladle of large size, which also rests on the ground. I employ small cupolas, also resting on the ground, for melting the spiegeleisen or recarborisation, and I arrange a crane, so that it commands all the machinery in the building except the cupolas themselves, the blowing engines, and the boilers.

'The crane lifts the ladles containing the molten pig iron and spiegeleisen, and automatically pours their contents into the converting vessels, without the intervention of runners of any kind. The ladle and contents are weighed on the crane, and the diminution of weight, as the pouring goes on, is indicated, so that by watching the index of the weighing apparatus, the regular quantity may be readily poured out. Regular steel ladles receive the steel from the vessels direct, and are carried away by the crane to the ingot moulds. One travelling crane will perform all the operations requisite for the manufacture of a large quantity of steel; if a very large production is intended, two travelling cranes can be used, or, in either case, equally good arrangements can be made with a jib crane. The traveller is by far the handiest crane of the two.

'The service of the vessels includes renewing the vessel bottoms when the refractory lining and tuyeres have been burnt away, and I arrange my plant so that the crane pulls the car out of the drying oven, and then, by means of a long peel or lever of suitable construction, raises the fresh tuyere plate and refractory bottom, and carries them into the proper position for attachment to the converting vessel. The worn-out bottom was, of course, previously removed by means of the same lever or peel.

'In order to make the tuyere box and bottom very light and convenient to be thus handled, I have designed a special form of tuyere box, which would be best designated by being called a tuyere plate.

'The converting vessels are so arranged that they need no chimneys of any kind, and that the flame, smoke, gas, and matter thrown out from the converting vessel, during the process of conversion, goes directly into the open air, the heavy matter falling on the ground outside the building.

'I provide a place for relining the ladles, so situated as to be entirely accessible from the outside, and quite out of the way of all other work. The drying ovens, and the engines, boilers, and pumps are disposed in a similar way, so that coal may be taken to the boilers, and refractory material to the drying ovens from the outside either by railway car, or on carts, without interfering in any way with other work.

'The cupolas are placed as near to the converting vessels as is consistent with comfort and convenience, but at the same time so that they may be in free communication with the outside. The pig iron, spiegeleisen, and fuel can thus be raised to the cupolas in any convenient way from the outside, and the slag and other *débris*, resulting from the operation of melting, go directly, in the shortest way, to the outside.

'The ingots are cast in an entirely separate and distinct locality, out of the vicinity of the vessels, and easily accessible from the outside of the building. This is done in order that the heat, resulting from the cooling of the hot ingot moulds after use, may be diminished as much as possible. Further, this arrangement enables us to perform the hot operation of casting the ingots away from the vessels, which are themselves

rendered very hot by the process of conversion. The heat to which the workmen are exposed is thus reduced as much as possible.

'The travelling crane is so arranged that it can itself, if desired, convey the hot ingots to the heating, or in this case cooling, furnaces, even at a long distance; or it can pile the ingots where needed, or handle them as may be convenient.

'I design, as you see, the blowing engines, boilers, and pumps, in such a way that they go into a small space and into a convenient position with reference to converting vessels and cupolas, and to the track laid in the building for the removal of ingots and the facilitating of repairs.

'All divisions, or part of the operation incident to the conversion of iron into steel, are so arranged that each of them, except partly the melting of the crude metal, may have a location such that no other operations are carried on opposite to it, thus securing greater convenience and freedom, from the fact that the operations are all carried on in areas adjacent but not opposite.

'An incidental though important feature in my design is, that the steel for ingots, or any metal in the course of handling, may be weighed while being poured, without further preparation. In the ordinary plants this cannot be done. There are many directions in which this feature can be made useful.

'The travelling crane may be run at any speed, and with one of about 40 ft. per minute the iron ladles can be taken from the cupolas to the vessels, and emptied in from 1 to 1½ minute. But a speed of 150 ft. to 200 ft. per minute is perfectly admissible for travel, 100 ft. to 150 ft. for cross motion of crab, and 50 for lifting ordinary weights. With these speeds a great amount of work can be done. One Brown's steam and hydraulic traveller, in the works at Landore, handles the ingots for 8 or 10 of Siemens' furnaces, doing all the work alone.

'In regard to the cost of the plant above described, I have detailed estimates which show that it can be built for from $65,000 to $80,000, depending on locality, to produce an average of at least 150 tons per day. It can be started with a single vessel, two cupolas, and the lowest basis for say 60 to 75 tons per day, for $45,000; and its capacity can be enlarged, up to the capacity of the cupolas, simply by extending the building in length. The estimated savings on all items, as compared with ordinary large plants, is not less than $2.50c. per ton, in addition to the large saving in interest.'

Steel, Cast, *Free Ammonia in.*—The following phenomena were observed in July, 1875, in a steel foundry near Paris, specially occupied with castings, generally from the crucible. They are thus described by M. Regnard:—

'One of the furnaces was on Ponsard's system, and in a large number of the ingots run from it I noticed, much to my surprise, the presence of free ammonia.

'It was under the following circumstances:—The Ponsard ingots, measuring laterally about 8 centimètres, used to be broken up for charging the crucibles, and while closely examining on one occasion the fracture of a freshly broken ingot, I was struck by a distinct odour of ammonia. I had a number of ingots at once broken, and observed the same phenomenon, if not in all, at least in a great number of cases. The characteristic ammoniacal odour was most distinct, and its presence was accompanied by that of a peculiar rushing sound, which was perfectly audible on applying the ear to the ingot. Attributing the noise to a disengagement of gas, I poured soap and water on the fractured surface, and a frothy substance of sometimes a cubic centimètre in volume was then formed, composed of thousands of microscopic bubbles. I called the attention of several men of science, Colonel de Reffye, M. de Beauchamp, and MM. Troost and Hautefeuille, among others, to this phenomenon.

'I renewed the experiment over and over again on a great number of ingots, from a hundred separate runnings of metal for remelting, and observed the following facts:—

'The disengagement of gas and the ammoniacal odour co-existed, and seemed to be in a direct ratio for intensity. Blister steel and mild steels generally had no trace of gas. The appearance of the fracture of the ingots which gave rise to gaseous disengagement was always the same, crystalline, and not quite uniform from circumference to centre. The ingots from the same running generally, but not invariably, exhibited similar phenomena. If tempered before fracture, the phenomena were absent. Usually it was from the very centre that the disengagement of the gaseous bubbles took place. This was easily verified by placing the fresh fracture under water.

'In some few days I collected in éprouvettes, from a hundred fractures, enough gas to proceed to analysis. The gas burnt with a scarcely visible flame; it exploded violently if mixed with air. The analysis showed that it was almost purely hydrogen, with perhaps a few traces of acetylene. Are we to conclude that hydrogen and nitrogen dissolved in the liquid metal, and prevented from escape by the sudden cooling caused by the ingot moulds, combine and form a true ammonium, NH^4, in alloy with

the iron? I have not been able to determine the question for myself, my attention having been otherwise taken up, but I thought that the publication of my observations might be of interest to those who study the chemical side of the manufacture of steel.'—*Les Mondes.*

PHOSPHORUS *in Iron and Steel.*—Dr. THOMAS M. DROWN, of Philadelphia, has the following remarks on the removal of phosphorus from iron in the puddling furnace:—

'The comparatively large amount of phosphorus removed by the DANKS puddler is due primarily to the intimate contact of the contents of the furnace with the oxide of iron of the lining and the abundance of basic slag, and, doubtless, also to the fact that the slag formed in the initial stage of the process is tapped off before boiling begins. It is a fact often overlooked that the elimination of phosphorus in the conversion of pig into wrought iron, whether by puddling or the BESSEMER process, depends first on the oxidation of phosphorus to phosphoric acid, and second on the retention of the phosphoric acid thus formed in the cinder. The practical difficulty lies not in the oxidation of the phosphorus, but in retaining it in its new combination. To do this we must have abundance of basic cinder. In the ordinary puddling process, as is well known, phosphorus may be very largely removed by the abundant use of oxide of iron. In DANKS' furnace there is always a surplus of oxide of iron, the extract of which, with the products of oxidation of the pig metal, is so very intimate that a still more complete and thorough action might be expected. Whether any of the phosphoric acid would be reduced at a high temperature, were the cinder allowed to remain in the chamber during the entire process, is doubtful, although this procedure would probably entail a considerable waste of lining.

'The BESSEMER process is a notable example of the non-retention of phosphoric acid in the cinder. Here it is impossible to have a basic cinder, as the lining of the converter is silicious.

'But not only is a high degree of basidity of cinder favourable to the retention of the phosphoric acid, but the stronger bases are more active in this regard than the weaker ones. The energetic effect of the soda—formerly used in the form of nitrate in the HARGREAVES and HEATON process—has been well shown. Lime has been used as a "dephosphoriser" in many forms, as, for instance, chloride and fluoride of calcium. SCHRMANN has lately proposed the use of a mixture of chloride of sodium and chloride of calcium. A great deal of vague theorising has been indulged in with reference to the action of these "dephosphorisers," the dissipation of the phosphorus in the form of some volatile combination being the favourite method of disposing of it. It is, however, most probable that in those cases where basic substances have proven themselves to be of value, it is simply by the retention of the phosphoric acid in the cinder by the strong base. If this view is correct, and if the action of the DANKS machine is what we have supposed it to be, then we may expect a still more favourable result in "dephosphorising" pig iron in the DANKS puddler, if we make the lining more active by the addition of alkalies or alkaline earths.

'There can be no reasonable doubt that, with a lining composed of a mixture of iron ore and lime, and possibly soda, the elimination of phosphorus would be nearly perfect.

'Mr. SNELUS, whose researches on iron are well known, has been using with advantage a furnace lining of an intimate mixture of iron ore and lime.'—*Transactions of the American Institute of Mining Engineers*, vol. ii. May 1873 to February 1874.

Phosphorus and Sulphur; their Elimination from Iron.—Mr. W. W. HEELEY read a paper, in December 1876, before the Mill and Forge Managers' Association on this subject. He contended that sulphur could only be eliminated by two processes, 'puddling' and 'physicking,' or mixing some oxidising body with the iron. Mr. HEELEY's remarks deserve every attention:—

'To secure the necessary purification intense heat was needed. In puddling by the old methods this was impossible, and so long as that method remained in vogue, physicking was a necessity, and should be resorted to. With new plants, such as the DANKS or SIEMENS, this was unnecessary. Still, even with those systems, he thought that better results could be obtained if some ingredients should be introduced which would cause a chemical reaction and displace the sulphur more quickly and more effectually. The process patented by JAMES HENDERSON for "making the purest steel or wrought iron from the most inferior pig, and to thoroughly eliminate all sulphur, phosphorus, and silicon, has produced varied results." The materials which HENDERSON used were:—100 parts Ringwood magnetic and titaniferous ores and 40 parts of fluorspar. Mr. HEELEY said that it had been proved frequently that as the percentage of manganese increased in pig iron so did the percentage of sulphur decrease. For example—if, in blast-furnace work, to ore and coke, which in the ordinary way would produce a pig containing from 2 to 3 per cent. of sulphur, manganiferous ore should be added, so as to put 2 per cent. of manganese into the pig, the sulphur would

be reduced to ·05 or ·08 per cent.; but when 2 per cent. of manganese was found in pig iron it never contained more than a slight trace of sulphur. As to the amount of phosphorus in iron, Mr. I. L. Bell had stated that 30,000 tons of phosphorus were annually sent away in the iron of the Cleveland district alone. If this were converted into phosphoric acid it would be worth 250,000*l.* as manure. Remaining in the iron it depreciated its value to the extent of 4,000,000*l.*, as compared with the same amount of hematite iron. This estimate, referring to one district alone, showed how vast would be the saving in respect of the aggregate product of the United Kingdom. There was, therefore, a wide field for chemical ingenuity in endeavouring to discover a method whereby the phosphorus can be successfully eliminated from the pig iron and made into valuable manures. For the sake of discussion Mr. Hurlet submitted the following propositions:—(1) Sulphur could only be eliminated by the processes already known and practised by the trade; (2) those processes were puddling and physicking; (3) mechanical puddling was the only puddling that could thoroughly effect the purpose; (4) if with their present plants they could not effectually eliminate sulphur by puddling, ought they not to try to do so by physicking? (5) would it be desirable that their employers should pay a little more attention to the composition of pig iron they were called upon to use, and let them have an analysis of the pigs, so that they might have sure data to work upon; and (lastly) did they, as managers, pay sufficient attention to those matters, or were they quietly permitting their trade to drift into other channels, as some asserted, or was it that other places had greater natural facilities and advantages?'

Steel, Phosphorus in.—Dr. Rossiter W. Raymond, as President of the Institute of Mining Engineers, in his address at St. Louis, referred to the law, said to have been discovered at the French works of Terrenoire, that the amount of phosphorus may be increased without injury to steel *if the amount of carbon be proportionately decreased.* The works named have been for more than a year manufacturing in the open hearth, by the Martin process, steel rails containing as high as 0·35 per cent. of phosphorus, with about 0·15 per cent. of carbon, which were not found inferior to Bessemer rails. It is not claimed by the manager of the works that phosphorus is an ingredient to be preferred, or purposely introduced; but only that materials containing it (such as old iron rails, &c.,) can be successfully employed. Other parties have apparently a higher opinion still of the new manipulation, and are prepared to claim for 'phosphorus steel' superior qualities.

After pointing out that the commercial value of the process turned on the cheap manufacture of ferro-manganese, by means of which only could the necessary amount of manganese be introduced into the Martin bath without increasing its contents of carbon, Dr. Raymond proceeded to say that the principle alleged to have been discovered at Terrenoire was already known years ago in America. Not only had steel been manufactured containing high percentages of phosphorus, coupled with low percentages of carbon, and suitable for use in rails, boiler-plates, &c., but the reason of its surprising qualities had been distinctly surmised if not widely proclaimed.

On this subject Mr. J. Blodgett Britton, Philadelphia, writes:—'I have examined a number of irons and mild steels (have frequently been puzzled to tell the difference), but in most cases the samples came without any collateral information, unless verbal, or in a form I cannot now quote. I made quite an extended examination of some of the Welsh rails that were first laid in this country. Some of them were in use 28 to 30 years, and when taken up were worked into axles and bridge rods, because of their remarkable toughness and strength; they contained from 0·204 to 0·385 per cent. of phosphorus and about as much silicon. It was long ago asserted by Karsten that bar iron might contain as much as 0·50 per cent. of phosphorus before showing cold short qualities, and up to 0·30 per cent. the only effect was to give hardness without affecting tenacity. But unfortunately he did not add how much carbon might be present, which was an important omission.

'Phosphorus exerts a marked influence upon the metal when associated with carbon; the more carbon the greater relatively the influence causing brittleness and frangibility at ordinary temperatures when in the slightest excess. The substance is nearly always present. If not relatively in excess it does not appear to be hurtful. Thus I have found 0·30 per cent. of phosphorus with 0·06 per cent. of carbon, and 0·08 per cent. of phosphorus with 0·20 per cent. of carbon, and in metals that were claimed to be very good.'

Mr. A. T. Hewitt writes:—'There is one other matter of equal importance. It seems to be settled that heads of rails wear better if the iron contains phosphorus, but is otherwise pure, that is, free from sulphur, and puddled so that there is no carbon left in the puddled ball. This is the key to the good iron rails made in Wales and in Westphalia. Heads that are to be made hard with carbon (puddled steel) should be free from phosphorus, and heads that are to be made hard by phosphorus

must contain no carbon or sulphur (in order to insure welding) and no silica (in order to insure sufficient tenacity). At Dowlais, if there is the slightest trace of carbon in the flame of the puddled ball it is sent back to the furnace, but the pig used is expressly made from ore containing phosphorus. In other words, it has been ascertained that iron containing phosphorus, but free from other impurities, is *good for wear* and next best thing for heads of rails to steel.'

Magnetism of Rails.—The following conditions appear to have been recently proved by the chief engineer of the railways in Hungary:—

1. Rails taken up after a number of years' use have a very feeble magnetic action; a steel rail having a section of 44 square centimètres (1 square inch is equal to 6·451 square centimètres) is, however, scarcely as powerful as a bar of steel, magnetised to saturation, of only half a square centimètre. Steel rails become much more magnetic than iron rails.

2. That rails in position are equally magnetic.

3. That rails placed in piles by the side of the road preserve their magnetism for some months, especially those of Bessemer steel.

4. That when a rail is broken the surface of the fracture presents opposite polarities.

5. That new rails placed in piles in the direction of the meridian become feebly magnetic, especially those of steel, which under the influence of blows from a hammer will become permanently magnetic.—M. Husson, quoted by the late David Forbes, in the *Journal of the Iron and Steel Institute.*

Notes by Editor.—1. The magnetic action in rails will depend entirely upon the direction in relation to the magnetic meridian in which they were placed. Steel naturally receives and retains magnetism more readily than iron.

2. This requires confirmation. I believe it will be found that a rail which has been placed N. and S. will become more magnetic than one placed E. and W.

5. Any piece of iron placed in the direction of the meridian and of the dip of the needle becomes magnetic when set in vibration by a blow of any kind. Steel of course retains its magnetism. Iron parts with it rather slowly.

STEEL RAILS. The following tables on the *Determination of Percentage of Iron in Steel Rails* are of much importance:—

Iron per Cent., weighed as Fe^2O^3, after deducting Silica and Phosphoric Acid	Iron per Cent. from Assay of Fe^2O^3, by Standard Solution of $K^2Cr^2O^7$	Total of Analysis
99·585	99·606	100·805
99·468	99·408	100·311
99·847	99·837	100·422
99·267	99·240	100·438
99·176	99·223	100·425
99·752	99·632	100·480
99·896	99·475	100·200
99·451	99·518	100·460
99·535	99·282	100·448
99·297	99·056	100·468
99·370	99·344	100·655
99·201	99·067	100·649
99·164	98·799	100·490
99·589	99·667	100·589
99·915	99·905	100·735
100·008	99·817	100·689
100·100	99·716	100·523
99·531	99·462	100·658
99·719	99·827	100·299
99·017	99·097	100·598
99·249	99·250	100·573
99·516	99·476	100·638
99·520	99·625	100·504
99·637	99·259	100·439
99·652	99·387	100·559
98·806	98·995	100·771
99·711	99·620	100·417
99·834	99·766	100·560
99·635	99·512	100·594

Iron per Cent., weighed as Fe^2O^3, after deducting Silica and Phosphoric Acid		Iron per Cent. from Assay of Fe^2O^3, by Standard Solution of $K^2Cr^2O^7$	Total of Analysis
	99·320	99·400	100·624
	99·210	99·247	100·541
	99·313	99·356	100·566
	99·670	99·480	100·636
	99·399	99·392	100·674
	99·703	99·506	100·856
	99·113	99·241	100·842
	98·792	98·825	100·569
	98·992	98·953	100·642
	98·429	98·624	100·331
	98·907	98·554	100·294
	99·682	99.280	100·449
	99·022	99.146	100·485
	99·627	99.699	100·554
	99·403	99·043	100·358
	98·882	98·782	100·425
	99·080	99·219	100·645
	99·142	98·964	100·450
	99·334	99·199	100·536
	99·414	99·271	100·495
	99·270	99·058	100·333
	99·094	99·036	100·328
	98·627	98·779	100·300
	99·187	99·030	100·366
	99·030	98·981	100·458
Soft metal .	100·259	100·291	100·674
,, .	100·207	100·154	100·281
,, .	99·844	99·891	100·285
	5,666·584	5,662·768	5,729·450
Mean . .	99·419	99·346	100·517
Mean difference		·073	

On the Estimation of Manganese in Spiegeleisen, and of Iron in Manganiferous Iron Ores, by Edward Riley, F.C.S.

STEEL FLUID, COMPRESSED, *for Guns, &c.* See Artillery, vol. i. p. 228; Fire Arms, vol. ii. p. 375; and Steel, vol. iii. p 900 to 910. Sir Joseph Whitworth has always contended that steel when made of the best materials, and obtained sound, with the relative degree of ductility and strength required, is the best material for guns.

In order to obtain steel of the requisite ductility and of a structure which can be depended on for being absolutely sound, extreme pressure must be applied to the metal when in the fluid state.

Sir Joseph Whitworth thus sums up the defects of steel. 'When highly carburised steel (such as tool steel) is cast in small ingots, and the air and gases escape rapidly by what is termed piping, about three-fourths of the length of the ingot will be sound and free from air-cells. If an attempt be made to cast a very large ingot of highly carburised steel, the lower portion may appear sound, as in the smaller ingot, but a new defect and difficulty arises from the fact that the material may crack and destroy itself in the act of cooling. The outside of the ingot sets first, and the inside is therefore exposed to a great strain while cooling. The strain may cause some part to crack or become unsound by reason of the hard unyielding character of the material.'

A member of the firm of Joseph Whitworth and Co., Limited, writes: 'I should be disposed to advance another explanation than this. In cooling, the outside sets first, and with comparative rapidity, relatively to the inner fluid portion of the ingot, consequently there is an outer skin of metal formed, the tension of which is very great, while the inner portions, cooling more slowly, assume a semi-crystalline condition. The natural tendency of such unequal portions will be to produce exactly the conditions represented in some of the sectional drawings of cast ingots given in *Guns and Steel*, by Sir Joseph Whitworth.

When guns of the ordinary weight are made of highly carburised steel, there can be no question but that the material is so strong, that it will, if *sound*, completely master the gunpowder. There remains, however, this danger of cracking and unsoundness in cooling which can never be entirely got rid of, and it must also be borne in mind that the material is hard and unyielding, and gives no notice before bursting. It is impossible, therefore, to manufacture a large gun of highly carburised steel, which can be relied on as being absolutely sound. The result of the breaking up of a gun made of hard steel would be terrific. Such accidents have happened, and hard steel guns are unsafe. The safeguard consists in employing steel possessing a higher ductility than tool steel. The material is not so strong, but the danger of breaking up is entirely overcome when the steel is free from air-cells.'

'To obviate the objections named Sir JOSEPH WHITWORTH employs fluid compression, which it is necessary now to describe:—

'The melted steel may be obtained from the crucible, from the BESSEMER converter, or by the SIEMENS-MARTIN process (see STEEL, vol. iii. p. 908), and pressure is applied to the fluid metal so melted as quickly as possible after it leaves the furnace.

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The mould box for fluid compression, shown in *figs.* 2388 and 2389, has an outer hoop of steel, A A, of the necessary thickness to withstand the pressure. The inside of this hoop is lined with a layer of cast-iron lags, B B, from the front to the back of which are a number of grooves or channels, by which the gases can reach the outer face of the lags, between them and the inside of the steel box; while communicating with these transverse channels are made a number of vertical or longitudinal channels, which open to the atmosphere at I I, at the top and bottom of the mould, and from which the escaping gases continue to burn for some time, when the pressure is applied to the fluid metal, S S. The inside of the mould is finally lined with a layer of refractory sand, which, while protecting the cast-iron lags from fusion by the heat of the melted steel, also permits of the gases being driven through it by the pressure to the back of the lags, and so to the atmosphere. The core is built up similarly to the mould.

Dr. TYNDALL thus describes the process witnessed by him:—'A large ladle was at hand, and into this was poured the molten metal from a number of crucibles. From the ladle again the metal was poured into the annular space just referred to, filling it to the brim. Down upon the molten mass descended the plunger of a hydraulic press. On first entering it a shower of the molten metal was scattered on all sides, but inasmuch as the distance between the annular plunger and the core on the one side, and the sheath on the other, was only about 1-10th of an inch, the fluid metal was immediately chilled and solidified. Thus entrapped, it was subjected to pressure which amounted eventually to about 6 tons per sq. in. Doubtless gases were here dissolved in the fluid mass, and doubtless also they were mechanically entangled in it as bubbles. I figure to myself the fluid metal as an assemblage of molecules with the intermolecular spaces in communication with the air outside. Through these

spaces I believe the carbonic oxide and the air to have been forced, finding their escape through the porous core on the one side and through the porous sheath on the other. From both core and sheath issued copious streams of gas, mainly it would seem in the condition of carbonic oxide flame. A considerable shortening of the fluid cylinder was the consequence of this expulsion of gases from its interior. The pressure was continued long after the gases had ceased to be ejected; for otherwise the contraction of the metal on cooling might subject it to injurious internal strains. In fact, castings have been known to be rent asunder by this contraction. By the continuance of the external pressure, every internal strain is at once responded to and satisfied, and the metal is kept compact.'

'The steel castings are forged by either the steam hammer, the rolls, or the hydraulic press, or a combination of these; but for large forgings generally there is a great superiority in the work produced by the hydraulic forging press. For the stroke of the press is that of a continuous pressure, and it is effective right through the mass of metal; whereas the blow of the steam hammer is largely expended within a short distance of the surface, while the centre of the work is for a certain period comparatively unacted upon, and therefore the different parts of the metal of the forging produced under the hammer exist in very different molecular conditions. This is not the case when the forging process is employed.

'The following table gives the tensile strength and the ductility of the different qualities of steel, while Table II. shows the results of experiments made with guns of different kinds of metal:—

TABLE I.—FLUID COMPRESSED STEEL.

Tensile Strength and Ductility of Different Qualities.

Arbitrary distinguishing Colours for Groups		Tensile Strength, Tons per sq. in.	Ductility, or percentage of Elongation	Purposes for which the Steel is available
		Tons	Per cent.	
RED	No. 1 No. 2 No. 3	40	32	Axles, boilers, connecting-rods, crossheads, crank pins, hydraulic cylinders, locomotive and marine cranks, propeller shafts, rivets, railway tyres, guide screws, gun furniture, gun barrels, air vessels for torpedoes, carriages for field and naval ordnance.
BLUE	No. 1 No. 2 No. 3	48	24	Cylinder linings for marine engines, slide-bars for locomotives, shafting, couplings, lathe mandrils, drilling-machine spindles, eccentric shafts for punching and shearing machines, pillars for hydraulic presses, large swages, pressure-blocks for riveting machines, hammers, hoops and trunnions for ordnance.
BROWN	No. 1 No. 2 No. 3	58	17	Large planing and lathe tools, large shears, drills, smiths' punches and dies and sets, small swages, cold chisels, screw tools, corn-mill rollers, armour-piercing shells.
YELLOW	No. 1 No. 2 No. 3	66	10	Boring tools, finishing tools for planing and turning.
Special Alloy with Tungsten		72	14	For particular purposes.

'In each group No. 1 represents the most ductile metal, and No. 3 the least ductile.

TABLE II.

Testing of Experimental Cylinders by Explosion of Gunpowder, showing the Comparative Strength of different Metals and of their Combinations as used in the different Systems of Guns.

No. of Cylinder	Description of Cylinders. Each 1½ in. diameter, ⅝ in. bore, 4 in. length. Cast Iron, Wrought Iron, Fluid Compressed Steel	Charges of Powder	Expansion in Diameter before Bursting	No. of Pieces when Burst
No. 1	Cast Iron	Grains 15	0·0000	No. 36
2	Wrought Iron, Staffordshire coiled	95	0·0997	5
3	Fluid Compressed Steel, No. 3 Red[1]	275	0·1659	2
4	Fluid Compressed Steel, No. 3 Brown[1]	325	0·0950	4
5	*Woolwich, Conversion of Cast-iron Guns.* Cast Iron, outside tube 0·1840 in. thick; Wrought Iron, inside „ 0·0660 „	30	0·0010	C 14, W 1[2]
6	PARSON'S *construction.* Cast Iron, outside tube 0·1442 in. thick; F No. 2 Yellow,[1] inside „ 0·1058 „	80	0·0009	C 132, F 25
7	*French construction.* F No. 2 Yellow,[1] outside tube 0·0900 in. thick; Cast Iron, inside „ 0·1600 „	90	0·0020	F 20, C 71
8	*Woolwich present construction.* Wrought Iron, outside tube 0·2083 in. thick; F No. 2 Red,[1] inside „ 0·0417 „	140	0·3080	W 7, F 1[2]

Mr. J. RAMSBOTTOM makes the following remarks in relation to the difference between iron and steel: He quite agrees in thinking the time has arrived when it is necessary to abandon the idea of drawing any definite line of demarcation between what was iron and what was steel. The distinction between the two had gradually faded away, and the materials denoted by such common expressions as a steely iron and a very mild steel, came so close together that he believed it would be very difficult for the most practical man always to say of a piece of metal whether it were iron or steel. It would therefore be a matter of convenience if the qualities of the different kinds of metal were expressed in definite language, in terms of the tensile strength and the power of elongation before fracture. Whether, when this was done, any such line of demarcation as had been suggested in the paper should be assumed for convenience, was an open question; but in ordering a material it would be a great convenience to be able to define exactly the character of the metal required in any particular case, because it was known how widely this varied at present under circumstances which seemed to be similar.

With regard to forgings of steel, whether compressed or otherwise, he had long been of opinion that it was difficult to have any steam hammer heavy enough for dealing with them. A blacksmith in drawing out a nail used a hammer very much heavier in proportion to the work than any of the steam hammers generally used for dealing with large forgings, the largest hammers being insignificantly small in relation to the work they had to do. There could be no doubt that the effect of compression by a hydraulic press was equivalent to that resulting from the blows given by a hammer of very greatly increased weight; under a continuous heavy pressure the inertia of the mass operated on was overcome, but that was not the case under the action of an ordinary hammer, because there was always some time occupied in the transmission of a blow to the interior of the mass, and the outside became more

[1] For explanation of these qualities of metal see Table I.
[2] The wrought-iron tube in No. 5 and the steel tube in No. 8 opened out in a single piece in bursting.

worked than the interior.—*Excerpt Minutes of Proceedings of the Meeting of the Institute of Mechanical Engineers in Manchester*, July 28, 1875.

Sir J. WHITWORTH remarked at the same meeting that, when the pressure of 6 tons per sq. in. was applied to the fluid metal in the mould, a column of fluid metal of 8 ft. in height was reduced 1 ft. in less than five minutes. No doubt there was a great deal of gas expelled during the compression, but he believed nine-tenths of it was common air; there was a portion of other gas mixed with the air, because it was burning while the pressure was on, but the greater portion he considered must be common air.

It had been pointed out that in casting ingots of steel in the ordinary way the metal was sometimes sound and sometimes not sound. His own experience had been that steel castings possessing 25, 30, or 35 per cent. of ductility or power of elongation, when pulled asunder, were never found to be sound; with 10 or 15 per cent. of ductility an ingot might be sound through 3-4ths or 7-8ths of its length from the bottom end; but he had never got it sound when the ductility was higher. The great value of a metal lay in its tensile strength and ductility combined. The best metal for guns, torpedoes, and boilers was that which had a tensile strength of 40 tons per sq. in., and had also 30 per cent. of ductility. The effect of this was that when it was burst it simply opened out, and therefore there was no danger. There was never much more than 30 per cent. of ductility in the compressed steel; in Low Moor iron 40 per cent. was obtained, which was about the limit practicable. It was impossible to get both high tensile strength and high ductility, because as one was gained the other was lost. In the case of the metal having a tensile strength of 40 tons per sq. in., and 30 per cent. of ductility, these two figures together amounted to a total of 70; and it was a great achievement to get so high a total divided in such nearly equal amounts between the two qualities of tensile strength and ductility.

On first commencing the manufacture of fluid compressed steel, in order to prevent confusion as to the different qualities of metal, he had called the softest metal red metal, the next in hardness blue, the next brown, and the next yellow; and each colour was subdivided into three numbers (see Table I.). No. 2 Red had a tensile strength of 40 tons per sq. in. and 32 per cent. of ductility, the sum of these two figures amounting to 72. No. 2 Blue had 48 tons strength and 24 per cent. of ductility, giving the same total of 72. Perhaps No. 3 Blue or No. 1 Brown would be the right material for a sword blade, possessing high strength and fair ductility also. No. 1 Brown, having 50 tons tensile strength, was the material of the long shot exhibited, which had gone through the 4½ in. armour plate. No. 2 Brown had 58 tons strength and 17 per cent. of ductility, the two figures amounting to 75, which was a higher total than was obtained, except occasionally, from a very ductile material. Again, the group of metal denoted by Yellow, which was suitable for tools for boring and turning, had 68 tons tensile strength, but only 10 per cent. of ductility, the total being 78. It would be a grand thing if with the 68 tons strength 20 per cent. of ductility could be got, because such a metal would be tough as well as hard. A special alloy of this Yellow steel with tungsten gave 72 tons tensile strength and 14 per cent. of ductility, making 86 total. It was tensile strength and power of elongation properly combined which gave value to the metal; and as there did not seem to be the means of getting more than about 30 per cent. of ductility, whereas the tensile strength could be increased through an extensive range, the important object to be aimed at was to preserve the 30 per cent. of ductility and to get with it as high a tensile strength as possible, as that could never be too great.

The remarks made on this fluid compressed steel by Mr C. W. SIEMENS are so important, and seem to explain so fully the peculiar character of the compressed metal, that it appears necessary to give them a place in this article:—In the plan now carried out, the steel after it had been produced was dealt with under a method entirely different from those before adopted, being here compressed while in a fluid or semi-fluid state. He had at first felt considerable doubt as to the effect of the new method. It was said that in applying hydraulic pressure upon fluid steel, the gases contained in the fluid metal would be driven out; but he could not see how that was to be done by mere pressure. For in applying pressure to a fluid, the pressure acted in all directions equally; and why a particle of gas held in suspension in the fluid should go in one direction rather than another, and should get away from the pressure to which it was subjected, it seemed difficult to conceive. The facts, however, spoke for themselves; and these being ascertained, it was more easy to find an explanation of what took place. The result he suggested might be accounted for by the circumstance that the fluid steel congealing first on the outside of the mould offered more resistance there to the motion of the plunger, and the outside thus became comparatively speaking porous, while the fluid portion in the centre received a larger amount of compression than the outside, which had more power of resisting the pressure. The particles of gas entangled within the fluid mass would therefore encounter rather

less resistance towards the outside than towards the inside, the full hydraulic pressure being transmitted to the centre of the fluid mass. In that way the expulsion of the gases from the fluid metal might perhaps be accounted for. The fact being admitted, it was clear that the steel produced by that mode of treatment must possess many great advantages over metal treated in the ordinary way by hammering; for it was hardly to be supposed that hammering would be capable of driving out the gases.

With regard to the mode in which these gases entered the metal, he did not think they were merely entrapped mechanically at the time of pouring out the metal into the mould; because in working melted steel in the open hearth of a regenerative furnace he had found that the metal could be made at any moment to evolve gases in great quantities by simply plunging a cold bar of iron to the bottom of the fluid mass. The fluid metal evidently absorbed carbonic oxide to a very great extent; and it was due to the partial congelation of the metal that the gases were suddenly set free. Similarly in the BESSEMER process a great ebullition took place on pouring the fluid metal out of the converting vessel into the iron moulds, and the top of the moulds had to be closed by a stopper to prevent the metal being thrown out by the ebullition. It was clear therefore that the metal contained a large quantity of gas occluded within itself; and if this was retained in the metal it became a source of weakness. However small the bubbles of gas might be, their presence would have the same effect as the presence of particles of foreign matter between the particles of metal, and must necessarily weaken it.

In reference to the proposal to designate as steel any metal bearing a tensile strain of 28 tons per sq. in., he thought it would be wise on the whole to fix a limit of strength, but some further limitation seemed also to be needed. For instance, a metal produced in the puddling furnace, with or without being converted into steel by the ordinary cementation process of making blister steel and shear steel, would have the required amount of tensile strength, and would therefore pass as a steel. But he considered a broad distinction should always be made between steel which had passed through the fluid condition and that produced by other processes, because the latter was deficient in one essential quality which was always sought for, namely uniformity of strength. He would therefore willingly accept the suggested definition of steel and iron according to tensile strength and ductility, if it were confined to metal that had passed through the fluid condition.

STEEL, CHROME.—The process of the manufacture of steel with chromium instead of carbon is of interest. In a general way steel is understood to be a combination of iron with carbon, the percentage of the latter constituent varying according to the character of steel desired. Of course the quality is also more or less affected by the process of tempering and other causes, but after ages of practical experimenting, carbon steel is far from perfection, unless the celebrated Damascus blades, made in Persia, Syria, and kindred countries, be carbon steel, which does not appear certain, for the process of their manufacture has been thus far kept a profound secret, though great efforts have been made to ascertain the method and materials employed. But, setting that aside, and looking only at the skill, money, and labour devoted for hundreds of years in England and other European countries to the manufacture of steel, and the efforts in France to produce a perfect imitation of the Damascus blade without avail, it may be safely assumed that, with carbon as a constituent, man can go no farther in steel making than he has already gone. To this conclusion both the practical and scientific world appears long since to have come, and attention has, in consequence, been much devoted to experiments in steel making with other substances as a substitute for the carbon. Carbon is not a metal, and the combination with iron in the shape of steel can hardly be called an alloy in the ordinary sense of the word. And it was probably with the idea suggested by this fact that experiments with iridium, chromium, and other metals were undertaken, and in one case, at least, that of chromium, rendered successful.

The CHROME STEEL COMPANY claims, among other excellences of its process, that it can produce grade for grade, and with perfect certainty, a quality of steel unequalled in tenacity. The alloys of iron and chromium are infinite, so that the guesswork of the skilled artisan in the carbon process is not necessary. In the latter the workman ascertains by the look of the iron the amount of the carbonisation, but in chrome steel such a mode of ascertaining the combination is superseded by weighing.

Another point is that chrome is the only metal which will weld perfectly to iron under the rolls. And, again, chrome steel can be worked in large masses without any injury by overheating, which is not the case with carbon steel, which, under long-continued heat, changes its character, or, as it is technically called, 'burns.' Chromium can only be separated from iron, after the alloy has once been made, by chemical analysis. Both are metals, and it requires a much higher temperature to melt chro-

mium than iron. It has very little, if any, affinity for oxygen, and chrome steels cannot be burnt by heating like a carbon steel. The chrome steel comes from the furnace and the rolls with a much smoother surface and texture than carbon steel. The tensile strength of the combination is much greater than that of carbon steel.

Experiments made with the chrome steel by the celebrated civil engineer, DAVID KIRKALDY, show that the maximum tensile strength of a $\frac{1}{2}$-inch bar, squared, hammered, and 5 inches in length, is equal to over 167,000 lb., and the lowest 115,000 lb. per square inch.

Other experiments with $1\frac{3}{4}$-inch bars gave, as the highest tensile strength of chrome steel, 199,000 lb., and the lowest 164,000 lb., while the highest of carbon steel is about 133,000 lb. per square inch. The process used by the CHROME STEEL COMPANY is that invented by Mr. C. P. HAUGHIAN.—*The Iron Age.*

IRON AND STEEL—SPECTRUM ANALYSIS *applied to Iron Manufacture.*—In the article on STEEL (vol. iii. p. 907), a short description of the application of spectrum analysis to the BESSEMER process of making steel has been given. (See also SPECTRUM ANALYSIS, vol. iii. p. 867.) This process has now assumed such a position that something more in detail appears necessary to guide the metallurgist in his application of the spectroscope to assist him in analysing the flame issuing from the BESSEMER converter, and for other purposes.

Professor ROSCOE, on March 27, 1871, delivered a lecture before the members of the Iron and Steel Institute, which was in many respects an admirable description of the application of spectrum analysis to the use of the metallurgists. It is, however, to be regretted that Professor ROSCOE has committed himself to some statements, respecting the character of the solar spectrum, which will not be found, I believe, to agree with careful observations of all the phenomena exhibited by that very beautiful chromatic band produced by the prism. Having accepted the undulating hypothesis as truly explaining the conditions of the solar variations, he has allowed himself to be misled as to the actual conditions observable in the distribution of light, heat, and actinism (chemical powers) in the banding of coloured rays. It is therefore necessary, as this lecture of Professor ROSCOE, published in the *Journal of the Iron and Steel Institute* (vol. ii. 1871), has deservedly attracted much attention, that a more careful examination of the solar spectrum should precede the description of its application to an examination of the flames issuing from a BESSEMER converter. Professor ROSCOE says:—

'If we study the character and properties of light in the various parts of the solar spectrum we find that the different portions of the coloured band possess very different properties. The heating rays—those rays which produce the effect we term heat—are situated almost altogether at the red end, and even beyond the red portion of the spectrum, so that the maximum of the heating effect in the solar spectrum is situated in the red rays. The maximum of the luminous effect is, however, situated in the yellow, whilst the heating rays gradually diminish in intensity as we pass to the more refrangible end, until they sink into almost an inappreciable quantity in the blue. But as we pass along from the red through the orange and green to blue, we find that the rays assume a different character; that is to say, they are capable of producing a different kind of action, or of doing a different kind of work, for when we come into the blue rays we find we have light capable of producing chemical action.

'These facts have been known for many years, and it has been customary to divide the solar rays into the heating, the luminous, and the chemically active rays, because it has been believed that there was a difference in kind between these three different sets of rays, so that it was thought that in a particular portion of the spectrum we could separate out the heating rays from the light-giving rays, and these again from the chemically active ones. Such, however, is not the case; we really have no more power of separating the light-giving portions of a blue ray from its chemically-active radiations than of splitting up a green ray into a yellow one and a blue one, which it is impossible to do. These various rays differ simply in wave length and in power of refrangibility.'

It is not a little curious to find this excellent chemist, immediately after this, giving two experiments, in one of which he distinctly admits that he separates the heat from the light, and in the other, that the '*chemically-active rays will be filtered off from the bulb by the red glass.*' In his *Spectrum Analysis* (MACMILLAN and Co., 1869) Professor ROSCOE makes the same statement. It is therefore essentially necessary to correct this, which can be done in a very few words.

Light.—All the rays conveying to the eye the sensation of colour are *luminous rays*: these are:—

1. *The Extreme Red Ray*, rendered visible by looking at the spectrum through a

piece of cobalt blue glass, as was first shown by Sir JOHN HERSCHEL. This ray exists below the ordinary red ray of the prismatic image.

2. *The Red Ray.*
3. *The Orange Ray.*
4. *The Yellow Ray.*
5. *The Green Ray.*
6. *The Blue Ray.*
7. *The Indigo Ray.*
8. *The Violet Ray.*
9. *The Grey or Lavender Ray*, which is seen when the spectrum is thrown upon paper dyed yellow with turmeric. This ray was also first observed by Sir JOHN HERSCHEL.
10. *The Fluorescent Rays*, which are rendered sensible to the human eye by throwing the solar rays upon a solution of sulphate of quinine or a decoction of the inner bark of the horse-chestnut tree, or on a crystal of fluorspar or on a piece of uranium glass. These results were first fully examined by Professor STOKES, consequently we have to deal with an extension of the luminous rays, or light, beyond the limits assigned to them by NEWTON.

The light, therefore, of the spectrum extends from the limits of the extreme red ray to the extension beyond the violet ray, which are marked by those rays which affect the human eye with a sensation of light only when caught upon certain peculiar media; the maximum of luminous power being in the yellow ray.

Heat.—Sir WILLIAM HERSCHEL was the first to determine with accuracy the distribution of the heating power of the spectrum, and Sir HENRY ENGLEFIELD, adopting additional precautions against any source of error, found that the thermometer was affected in the order following in the different rays, beginning at the most refrangible end of the spectrum:—

In the *Blue Rays* . . .	it rose in	3′	from	55°	to	56°	or	1°
" *Green Rays* . . .	"	3′	"	54°	"	58°	"	4°
" *Yellow Rays* . . .	"	3′	"	56°	"	62°	"	6°
" *Full Red Rays* . . .	"	2½′	"	56°	"	72°	"	16°
" *Confines of Red Rays* . .	"	2½′	"	58°	"	73½°	"	15½°
Out of visible light . . .	"	2½′	"	61°	"	79°	"	18°

Sir JOHN HERSCHEL, by throwing the spectrum upon pieces of blackened bibulous paper washed with ether, has traced, by their evaporative power, the action of the heat rays still further into the most refrangible rays—*i.e.* to the extremity of the violet, and to a distance below the visible rays of least refrangibility, far greater than had been hitherto suspected.

Actinism.—The Chemical Rays.—If the prismatic is thrown upon a piece of paper coated with the chloride of silver, it will be found that a change—a decomposition of the chloride of silver indicated by darkening—will commence in the middle of the blue ray, and rapidly go on over the indigo and the violet rays, extending far beyond the violet, over the lavender, and the space occupied by the fluorescent rays. While this is going on it will be found that evidences of chemical action are manifested in the red ray. Upon papers prepared with the bromide of silver the chemical action is gradually set up over the whole of the spectrum, from the lower red to the extreme of the ultra-spectral rays beyond the violet, excepting only a small portion of the yellow rays, the maximum of luminous intensity.

There are three distinct classes of phenomena evident in the spectrum:—

Light.—The rays producing colour, and to which all luminous phenomena belong.

Heat.—The rays producing the sensation of heat and all calorific phenomena.

Actinism.—The rays which are active in producing chemical change, and upon which all the phenomena of photography depend.

These can be separated one from the other, and the effects of each exhibited without the interference of the other's forces.

By a pure yellow medium, as a glass stained throughout with a salt of silver, the light can be filtered from the chemical rays.

By a dark cobalt blue glass nearly all the light rays can be stopped, and the chemical rays allowed to pass and do their work of chemical change freely.

By a piece of black mica—by a solution of iodine in disulphide of carbon—all the light and the chemical power can be interrupted, and as Dr. TYNDALL and Professor ROSCOE has shown, heat manifested in all its power.

The real explanation appears to be that the prismatic image of the sun consists of *light*, which extends from the lowest visible red to the end of the occasionally visible fluorescent rays; of *heat*, extending from a space where no light has yet been detected beyond the extreme red, having its maximum of power at the lowest edge of the ordinary red, and fading gradually until it is lost in the violet; and of *actinism*,

which has its ordinary maximum in the violet rays, extending with great power over the space covered by the fluorescent rays; and in the other direction to the yellow ray, where the chemical influence is lost, to be recovered again in the red ray. Whatever theory may be adopted to explain these phenomena, there cannot be a question but that the results are as they have been stated. With this explanation of the real condition of the solar rays we must now pass to the consideration of a peculiar set of phenomena which belong to light alone.

When we look through a telescope at a good solar spectrum formed by allowing the sun's rays to pass through a fine slit, we see that the coloured band is crossed by numerous dark lines. Dr. Wollaston was the first to notice these lines. They were subsequently examined with much greater care by Fraunhofer, and he mapped 576 of these lines. He ascertained that these lines are present in sunlight under all circumstances, that they could be detected in the light of the moon, and in that of the planet Venus, as well as in the radiations from the fixed stars.

Professor Miller, Sir David Brewster, and others, examined and mapped these dark lines in the spectrum, and they observed also that certain substances which gave colour to flame, gave, when this coloured light was passed through a prism, spectra consisting of brilliantly-coloured lines. The examination of this branch of the inquiry passed into the hands of Kirchhoff and Bunsen (see their memoir on Analysis by Spectrum Observation, *Phil. Mag.*, vol. xx., 1860). The following quotations from this memoir will show the exceeding delicacy of this beautiful mode of examination. The first quotation describes the formation of several coloured bands, all of which are marked in the figure of the spectrum. The second quotation refers to one substance—sodium—only, but it should be stated that in an equally delicate manner almost every element is indicated by the position of its coloured ray or rays in the spectrum and some peculiar characteristic.

'It is well known that certain salts possess the property of imparting colour to flame. Common salt, for example, gives a yellow colour, the salts of strontian impart a red colour, those of barytes tint the flame green, copper gives a bright green, and so on. Almost every chemical compound imparts some peculiar colour. If the flame is examined by a prism it will be found that the colour of each particular flame possesses a special degree of refrangibility, and if the spectrum has been correctly formed, a band or bands of the colour emitted by the flame, but purer, will be distinctly shown. If a mixture of salts is used to impart colour to the flame, the rays belonging to each appear divided out, and an experiment, described by Kirchhoff and Bunsen, shows this so clearly that it is thought advisable to extract it from their paper on the subject.

'A mixture of the chlorides of potassium, sodium, lithium, calcium, strontian, and barium, containing at most $\frac{1}{10}$th of a milligram of each of these salts, was brought into the flame, and the spectra produced were observed. At first the bright yellow *sodium line*, Na α, appeared with a background formed by a nearly continuous pale spectrum; as soon as this line began to fade the exactly defined bright red line of *lithium*, Li α, was seen; and still further removed from the sodium line the faint red potassium line, Ka α, was noticed, whilst the two barium lines, Ba *Ba B*, with their peculiar form, became visible in the proper position. As the potassium, sodium, lithium, and barium salts volatilised, their spectra became fainter and fainter, and their peculiar bands one after the other vanished, until after the lapse of a few minutes the lines Ca α, Ca β, Sr α, Sr β, Sr γ, and Sr δ became gradually visible, and, like a dissolving view, at last attained their characteristic distinctness, colouring, and position, and then, after some time, became pale and disappeared entirely.'

'The following experiment shows that the chemist possesses no reaction which in the slightest degree will bear comparison, as regards delicacy, with this spectrum analytical determination of sodium. In a far corner of our experiment room, the capacity of which was about 60 cubic mètres, we burnt a mixture of 3 milligrams of chlorate of sodium with milk sugar, whilst the non-luminous colourless flame of the lamp was observed through the slit of the telescope. Within a few minutes the flame, which gradually became pale yellow, gave a distinct sodium line, which, after lasting for 10 minutes, entirely disappeared. From the weight of sodium salt burned and the capacity of the room, it is easy to calculate that in one part, by weight of air, there is suspended less than $\frac{1}{20000000}$th of a part of soda smoke. As the reaction can be observed with all possible comfort in one second, and as in this time the quantity of air which is heated to ignition by the flame is found, from the rate of issue and from the composition of the gases of the flame, to be only about 50 cubic cent. or 0·0647 grm. of air, containing less than $\frac{1}{20000000}$th of sodium salt, it follows that the eye is able to detect with the greatest ease quantities of sodium salt less than $\frac{1}{3000000}$th of a milligram in weight. With a reaction so delicate it is easy to understand why a sodium reaction is almost always noticed in ignited atmospheric air. More than

two-thirds of the earth's surface is covered with a solution of chloride of sodium, fine particles of which are continually being carried into the air by the action of the waves. These particles of sea-water cast thus into the atmosphere evaporate, leaving almost inconceivably small residues, which, floating about, are almost always present in the air, and are rendered evident to our eyesight in the sunbeam. These minute particles perhaps serve to supply the smaller organised bodies with the salts which larger animals and plants obtain from the ground. In another point of view, however, the presence of this chloride of sodium in the air is of interest. If, as is scarcely doubtful at the present time, the explanation of the spread of contagious disease is to be sought for in some peculiar contact action, it is possible that the presence of so antiseptic a substance as chloride of sodium, even in almost infinitely small quantities, may not be without influence upon such occurrences in the atmosphere.'

The dark lines, named after FRAUNHOFER, of which we have already spoken, are but a reversal of those bright lines. In fact, the dark lines of the spectrum represent the luminous rays, with their light extinguished. KIRCHHOFF states, as the result of his experiments, that glowing gases have the power of especially absorbing rays of the same degree of refrangibility as those they emit; and that, therefore, the spectrum of such a glowing gas can be reversed, or the bright lines turned into dark ones, when light of sufficient degree of intensity, giving a continuous spectrum, is passed through it. This idea was further confirmed by substituting for the sodium flame—the flame coloured by potassium—when *dark* lines appeared in the exact position of the characteristic bright lines of this metal. BUNSEN and KIRCHHOFF have likewise succeeded in reversing the flames of lithium, calcium, strontian, and barium; and Dr. MILLER has also reversed some of the lines of the spectrum of copper.

The application of spectrum analysis to the manufacture of steel now claims our attention. In the article STEEL, vol. iii. pp. 902–908, a detailed description of the BESSEMER process is given, with a brief account of the application of the spectrum analysis for the purpose of determining the exact moment when the iron in the converter is in the condition of the finest steel. It must be understood that those who have been accustomed to work this process can tell, with great exactness, from the change in the character of the flame proceeding from the converter, the period at which the air should be turned off. The spectroscope ascertains, beyond the shadow of a doubt, the moment when all the carbon is burnt off, and so does the eye of the experienced workman.

Professor ROSCOE says: 'By a simultaneous comparison of the lines in the BESSEMER spectrum with those of well-known substances, I was able to detect the following substances in the BESSEMER flame—sodium, potassium, lithium, iron, carbon, hydrogen, nitrogen. At a certain stage of the operation, all at once the carbon lines disappear, and we get a continuous spectrum. The workman, by experience, has learned that this is the moment at which the air must be shut off, but it is only by means of the spectroscope that this point can be exactly determined.

'Those who are practically engaged in working this process would like spectrum analysis to do a great deal more; they would like to be told whether there is any sulphur, phosphorus, or silicon, in their steel: questions which unfortunately at present spectrum analysis cannot answer, for this very good reason, that these substances do not appear at all as gases in the flame, but that they either remain unvolatilised in the molten metal, or swim on its surface in the slag of the ore, and consequently the lines of these bodies are not seen in the spectrum of the flame.' The subject is, however, so important that the experiments made by Dr. MARSHALL WATTS deserve great attention.

Dr. W. MARSHALL WATTS, in the *Philosophical Magazine* for December 1867, published some results obtained by him at the LONDON and NORTH-WESTERN COMPANY'S works, at Crewe, from observations on the spectrum of the BESSEMER flame. 'These experiments showed that the BESSEMER spectrum contained, besides the lines of potassium, sodium, and lithium, certain lines due to iron; but most of the lines were not found to be coincident with the known lines of carbon or of any other element. Nevertheless I held strongly the opinion that the spectrum was mainly due to carbon for the following reasons:—

a. Carbon is known to give more than one spectrum (*Philosophical Magazine*, October 1869; *Chemical News*, October 1870), and though the BESSEMER spectrum does not coincide with any recognised spectrum of carbon, it is yet observed in the flame of burning coke, and in other cases where carbon would seem to be the essential element present.

b. The spectrum disappears almost entirely at the right moment for stopping the blast, which is supposed to be when the carbon in the pig iron has been burnt out, and the iron is in the condition of molten wrought iron.'

In February 1873, Dr. W. MARSHALL WATTS published in the *Philosophical Maga-*

zine the results of some other experiments made at the Hematite Iron and Steel works at Barrow.

The uncertainty which appears to attend these results is to a great extent removed by Dr. Watts, who thus describes his experiments at Barrow:—

'The observatory was placed against the wall of one of the sheds, about on a level with the top of the converters, close to two converters, and commanding a distant view of two others. The distant converters were found to be the best for careful measurement, the shaking being less than when the blow was taking place at one of the near converters, although the spectrum from these was of course the most intense. The best method of introducing the reference spectrum was found to be to throw an image of the Bessemer flame upon the slit by means of a large lens of about 10 in. focus, and to bring the spark discharger (or Bunsen burner) between the lens and the slit. A screen was arranged so as to cut off the light of the Bessemer flame when required, so that either of the two spectra could be obtained alone at pleasure, or the one could be superposed on the other.

'The metals employed to furnish the reference lines were the following—besides which the lines of the air spectrum were made use of—aluminium, copper, cadmium, iron, lithium, lead, magnesium, manganese, platinum, sodium, thallium, tin, and zinc. Further, the Bessemer spectrum was carefully compared with various spectra, especially those of iron, sodium, lithium, manganese, and oxide of manganese. The spectra were either arranged under the Bessemer spectrum by the use of the reflecting prism, or were superposed on it. The spectra of iron and manganese were obtained by taking the electric spark between wires of these metals, the spectra of soda, lithium, and oxide of manganese by the use of a Bunsen burner, or by heating the substance in the flame of the oxyhydrogen blowpipe.

'When chloride of manganese (or carbonate of manganese or pyrolusite) is heated in the oxyhydrogen flame a very brilliant spectra is obtained, which *is for the most part coincident* with the Bessemer spectrum. Observations were further made on the spectrum, obtained on adding the spiegeleisen, on the temperature of the flame at different stages of the process, and on the differences in the spectrum caused by the employment of different iron.'

The spectrum of the Bessemer flame must be regarded mainly as the spectrum due to the oxide of manganese or to spiegeleisen. A few of the lines observed in the iron spectrum are evident in it. As Dr. Watts remarks: 'The identification of these iron lines proves that iron may exist as vapour at a temperature below the melting point of iron, since the Bessemer flame is not hot enough to melt wrought iron, nearly 30 lines in the Bessemer spectrum remain unidentified.'

Analytical examination shows the changes which take place during the process of converting iron into steel by the Bessemer process:—

	Iron 1	— 2	— 3	— 4	Steel 5
Graphite	2·570	—	—	—	—
Combined carbon	1·000	3·040	1·640	0·190	0·370
Silicon	2·260	0·955	0·470	trace	trace
Phosphorus	0·073	0·070	0·070	0·070	0·050
Sulphur	0·107	0·091	0·098	0·093	0·090
Manganese	0·410	trace	trace	trace	0·540

1. Original pig iron.
2. Metal taken at the end of six minutes.
3. ,, ,, boil twelve minutes.
4. ,, ,, blow.
5. After the addition of spiegeleisen.

It is well known that it is necessary to cut off the blast at the moment when all the carbon is burnt off from the iron. Now let us examine what the spectrum tells us. The stages through which the Bessemer process passes may be divided into four. The Bessemer flame at the beginning gives a continuous spectrum, without a break, extending from red to violet. At a certain period, varying according to the temperature, and according to the time which the whole operation takes, certain lines begin to make their appearance. When this action has gone on for a certain time a change comes over the whole spectrum, lines begin to make their appearance in almost every portion of the bright band, and at last a most complicated series of dark and bright bands and lines appear. This very complicated spectrum has not yet been satisfactorily made out; it is exceedingly difficult to determine to what substance some of the lines belong. At a certain period of the blow, these lines and bands suddenly disappear,

and in the last stage of the operation, the spectrum of the second period is repeated, and this is exactly the point at which the flame drops, and which has been found in practice the moment at which the blast should be turned off.

We do not get, as we might expect, a defined carbon spectrum. Professor ROSCOE describes several varieties of the spectrum bands produced under certain conditions by carbon; but none of these exactly agree with the spectrum obtained from the BESSEMER flame. 'Still,' he says, 'I think there is little doubt, seeing, in the first place, that carbon does give us other different spectra, that this BESSEMER spectrum flame is, in fact, another modification of the carbon spectrum.

'It is a remarkable fact that it has not been found possible, artificially, to get this peculiar spectrum, which is seen in the BESSEMER flame, and seen in other flames—seen, for instance, in that beautiful flame which is emitted when the spiegeleisen is allowed to run in. It has also been seen by Dr. MARSHALL WATTS, in the bright white flame issuing in the hot-blast furnace when they run out the metal, and turn the blast down through the bottom of the furnace.'

Another application of spectrum analysis has been very satisfactorily made by Sir JOHN G. W. ALLEYNE, Bart., of the Butterley Iron Works, in Derbyshire. This is the estimation of small quantities of phosphorus in iron and steel. Sir JOHN ALLEYNE brought this matter before the Iron and Steel Institute, and a paper was published by him in the *Journal of the Iron and Steel Institute*, No. 1, for 1875. From this paper the following extracts are made, by the kind permission of the author:—

'Taking up the subject, then, where Professor ROSCOE left in March, 1871, the author had first to get a spectrum of iron, and to find the requisite apparatus. Mr. ALFRED APPS, of the Strand, furnished a powerful GROVE'S battery, an induction coil capable of giving a spark of 12 in. between the secondary poles, and a LEYDEN battery of 4 one-gallon jars. The coil was of very much the same construction as that which he has now lent to further illustrate this paper. A spectroscope, by Mr. JOHN BROWNING, with a battery of four prisms of dense flint glass, formed the first batch of

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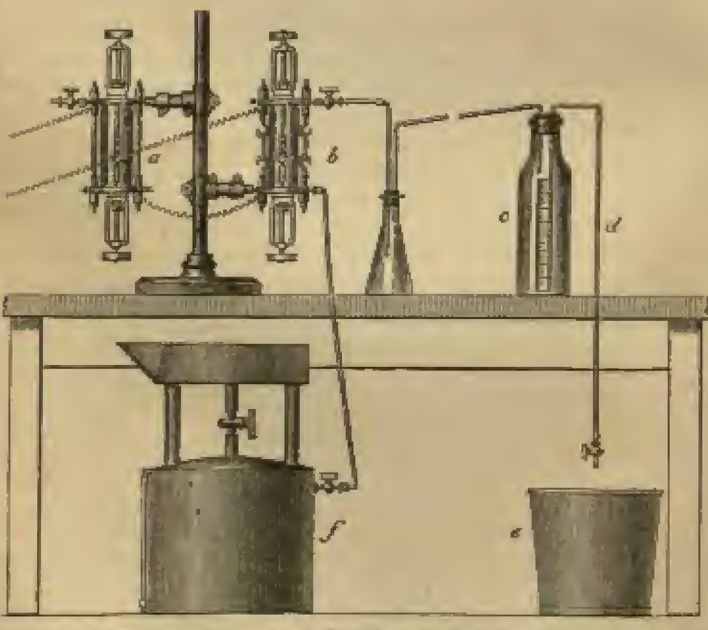
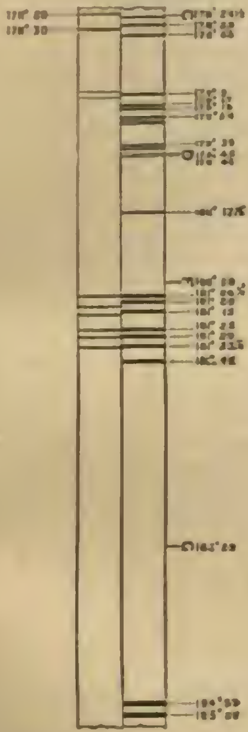


apparatus. Professors ANGSTRÖM and THALÉN state that there are 460 lines in the spectrum of iron. Dr. WATTS, in his index of spectra, gives—KIRCHHOFF, 71; THALÉN, 148; HUGGINS, 101; but there are also present the atmospheric lines, which, in his index of spectra, give—HUGGINS, 32 for oxygen, and nitrogen 78. The question first to be decided was, which of all that multitude of lines are atmospheric lines, which sulphur, calcium, manganese, phosphorus, &c. It was very soon

obvious that the spectra obtained from Geissler's vacuum tubes, although most beautifully made and contrived, gave the spectra under totally different conditions from those in which they exist in our iron. After many trials and experiments, with the details of which it is needless to trouble the Institute, he determined to work wholly by spectra of comparison. But considerable difficulty arose with silica, alumina, and sulphur, as well as phosphorus—first, as to the means of holding them as electrodes; secondly, they are very bad conductors. A piece of fire-brick, held in the nippers, will give no spectrum; the spark jumps over it in the most clever way, and gives nothing but the spectrum of the nippers, be they brass or steel. Some of the small tubes were made—they are shown at *fig.* 2390 in the diagram. The object here was to bury the electrode in the pounded fire-brick, and force the current to pass through it. These are obviously a modification of Geissler's tubes. The lines of silica and alumina shine out with splendour, but they do not last long, the glass gets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coated with the material which is decomposed by the spark, and forms a conductor, the spark only passing in fitful flashes, and giving but very little light; on the whole, the best way of charging the tube is, to allow the platinum electrode to come through the throat of the tube, and burying the lower electrode in the powder under examination. This has the farther advantage that the spectrum of the glass itself does not intrude; the lines of the platinum must, of course, be noted, and not confused with those of the powder. The spectra of iron ores come out very well by this method. The nozzles *a b* (*fig.* 2393) are for letting in gas. This being the most difficult spectrum with which the author has had to deal, he has thought it better to explain it before proceeding to phosphorus, which forms the main subject of the paper. The phosphorus lines were got in this way—a small hole was drilled into a piece of carbon and filled up with phosphorus, the phosphorus worked over the carbon like the head of a rivet, so that the spark could not get from one carbon electrode to the other without volatilising the phosphorus; but it is quite obvious that this method would not do in atmospheric air; the spectrum must be taken in a gas with which the phosphorus could not enter into combustion or it would

simply light in the spark, combine with the oxygen, and fill the cylinder with phosphoric acid. Carbonic acid, hydrogen, or the common coal gas, all do very well for this. A special apparatus, however, had to be fitted up, and is shown on the drawing at *fig.* 2390. The lines of phosphorus on a carbon point, taken in this way in coal gas, are shown on the spectrum on the drawing at *fig.* 2391. It will be seen at once that the characteristic features of phosphorus are seven broad bands in the green; there are also three very peculiar lines in the red, like a wicket, with the middle stump thinner than the other two. There is also the same kind of group in sulphur, but in a different position in the red, by no means coincident. The lines of both sulphur and phosphorus are got by comparison: that is, one pair of electrodes were prepared with a phosphorus point, as before described, and another pair, from exactly the same carbon, were prepared without phosphorus; each pair was fitted into one of the glass cylinders, the cylinders were filled with coal gas, each with a separate branch pipe, and the gas lit, the pair of plain carbon electrodes were arranged in front of the slit of the collimator of the spectroscope, and the phosphorus pair were arranged opposite the cross prism, or prism of comparison. The two spectra are seen—the phosphorus above, and the carbon below, in the usual way. The lines which coincide are those of carbon and coal gas, a beautiful spectrum well worthy of study. The lines which do not coincide are those of phosphorus and anything the phosphorus may contain; the readings on the dividing plate must be carefully noted. We have now to look for phosphorus in our iron. The plain carbon points must be removed—the nippers replaced with a clean pair, the cylinder covers cleaned, and the iron electrodes, to be examined, put in. The iron is now in air, the phosphorus in coal gas, the lines which coincide are produced by phosphorus in the iron which is decomposed by the spark, taking care to note which were the readings taken as phosphorus lines in the last experiment, for there may be silicon, sulphur, and other impurities in the carbon—there is certainly also carbon itself—all of which are present in the iron. There is, however, little or no risk of any confusion on this point. All the coincident lines in ordinary pig, puddled, or bar iron, are in the green or very near to it. The seven lines or bands of the phosphorus are much broader, those of fairly good iron, very fine, sharp, and bright. The idea struck the author, are not those iron lines brighter than the phosphorus itself, because they are in an atmosphere containing oxygen? The question was soon put and answered, the coal gas was let into the iron cylinder, and the lines vanished entirely; but the spectrum of coal gas does not suit very well for this purpose. It has numerous lines of its own, which have to be eliminated; the part of the spectrum—the green—where the characteristic lines of phosphorus occur, is ruled all over by the most extraordinary number of dark absorption lines, through the intervals of which the brighter parts of the continuous spectrum of the spark are seen. It is most difficult to determine whether these are, as supposed, bright spaces of a superimposed spectrum or lines. Hydrogen gas is much better as an absorber, or as a gas in which, oxygen being absent, no combustion can take place. It is needless to point out here that, in using hydrogen, the greatest care must be taken to avoid explosions. The practice in these experiments has been to fill all the cylinders and pipes with coal gas, light it, and to displace this gas with hydrogen. It is found that, when there are 12 cub. in. of hydrogen, as measured by the graduated bottle hereafter to be described, the carbon rulings (if that can be accepted as a proper term) disappear. The lines of the spectrum, which in air are bright, and which coincide with those of phosphorus and sulphur, are completely blotted out or absorbed. The conclusion which the author has come to is that when small quantities of phosphorus or other matters are present in the electrodes, they require oxygen in some form to bring them out as bright lines. He is confirmed in this view by other writers. In SCHELLEN's *Spectrum Analysis*, p. 162, he says: "If a few grains of common salt be dropped into the flame of a BUNSEN burner, there is emitted an intense light of one colour, producing the spectrum of a single yellow line. If the temperature of the flame be raised by a further supply of oxygen, the brilliancy of this line is immediately augmented, and the number of coloured lines so much increased, as to approach somewhat to a continuous spectrum." It may be that the lines are only obscured by the spectrum of hydrogen as a screen, or as a piece of coloured glass. If this should prove the correct explanation, it can, just as well as the first supposition, which the author has accepted as the true one, be used as a means of measuring the quantity present in the spark, and arriving at a correct estimation of that quantity by spectrum analysis. By the first supposition, we calculate the quantity inversely, as the quantity of oxygen, or a compound of oxygen used; by the second, we alter the character and condition of the screen, it becomes less dense by admixture with the oxygen compound, until the line is able to penetrate. If a large quantity of phosphorus is undergoing deflagration at the electrodes, it will penetrate a screen of considerable density. If a small quantity only is undergoing decomposition, the density of the screen must be reduced until

the line can penetrate it; in either case the quantity can be estimated inversely, as the quantity of oxygen that has been used. In comparing a phosphide of iron with phosphorus, or a sulphide of iron with sulphur, the quantity of sulphur and phosphorus has power to penetrate the gas, but some of the lines at the red end of the spectrum are missing. To return, then, to the main subject of the paper. At *fig.* 2391 are shown the characteristic lines of phosphorus; the lines were taken, as before described, on carbon electrodes tipped with phosphorus—some lines, which are exceedingly fine, have been omitted as doubtful. In this spectrum we have 21 lines; Dr. WATTS gives 47, as found by PLÜCKER, but as to how the spectrum was taken, whether as a vapour at atmospheric pressure, or in a vacuum tube, he gives no information. The principle, which the author has introduced, of course requires further investigation; but the fact does seem to him to be confirmed by such experiments as he has been able to apply, which is this, that an atmosphere of hydrogen gas, or a gas composed of the ordinary coal gas from the gas works, with an admixture of hydrogen, has power to absorb completely the phosphorus lines in iron, even when there is as much as 3·234 per cent. of phosphorus present—that no sign of phosphorus is seen in the spectrum in an atmosphere of this gas—that on the admission of a very small amount of oxygen, the line does not appear—that when very small quantities of phosphorus are present, a very much larger quantity of oxygen must be admitted, to make the line shine out as a bright line. The experiments which have led to this result have spread over many months, and have absorbed almost all the author's leisure time; they will, however, be explained in a few minutes. They extend over several samples of iron, from which a selection has been made, ranging from ·560 of phosphorus to ·021. We propose, in this case, to deal with materials suitable for the SIEMENS steel furnace, either by Dr. SIEMENS' open-hearth furnace or by the SIEMENS-MARTIN process. For the quality we propose to make we will assume that we must not have more than ·050 of phosphorus. A few pieces are chipped from the pig iron to be used; from these a pair of electrodes are filed up, they are placed in the nippers, and put into the glass cylinder shown at *fig.* 2392. We should place the phosphorus electrodes themselves in the cylinder, let coal gas into it, and turn on the current; when the spectroscope is adjusted, we should see that there are seven broad lines in the green, that the band marked 181° 6¼′ in the green has a decided unmistakable coincident in iron. The current must not be kept on long, for as the iron is in air it will be very rapidly coated with oxide. Except to satisfy the observer that it is coincident, it is better not to turn on the current when the iron is in air, because the oxide will be decomposed, and upset the subsequent calculations. Coal gas is next let into the cylinder and pipes, and lighted at such portion of the pipes, and at the cylinder, as will ensure that all the atmospheric air has been driven out. The hydrogen gas holder is now connected, and the gas turned on. At *fig.* 2390 of the drawings the graduated bottle is shown; this bottle is $3\frac{15}{16}$ in. diameter, so as to get 12 in. area. The bottle actually used in the experiments is an old barley sugar bottle, and can be graduated accurately to whatever its diameter may be, by weighing 12 cub. in., marking the space on the bottle, and graduating it accordingly. This bottle forms a very important part of the apparatus. It is fitted with a syphon pipe, shown at *fig.* 2390. When the cock at the long leg is opened, and all the cocks to the cylinder and gas holder are also opened, the water runs out of the bottle into the bucket shown. The coal gas in the cylinder flows out and takes its place, and the hydrogen from the gas holder follows and takes the place of the coal gas, or mixes with it. The practice in these experiments has been to let in, in this way, 12 cub. in. of gas as measured by the bottle, and to examine the spectrum for air lines; the practised eye will detect these in a moment. If the air lines are in the spectrum, this gas is not pure, oxygen is present, the hydrogen is unfit for use, or the pipes have not been properly cleared of air. With 12 in. of hydrogen which has been carefully prepared, the line, the reading of which on this particular instrument is 181° 6¼′, is completely blotted out, and there is a continuous hazy-looking spectrum with indications of lines at various parts, but the line 181° 6¼′ has completely vanished. We have next to ascertain what quantity of oxygen will be required to make 181° 6¼′ come out as a bright line. The hydrogen must be disconnected, and carbonic acid connected, taking care, of course, to exclude the air. 30 cub. in. are required to bring out a bright line. This iron may, with confidence, be passed and used; it drops on to the curve just at 30, showing that it has ·021 per cent. Supposing that we are working the SIEMENS-MARTIN process—the next sample submitted to the spectrum analysis we will suppose to be puddled iron; it is tried with hydrogen and there is no line, the carbonic acid is let in as before, at short intervals, and in quantities as measured by ¼ on the graduated scale, which is equal to 3 cub. in.; with the second admission of 3 in., making in all 6 cub. in., the line is bright; thus the iron is very bad; it contains ·560 of phosphorus, and

may, with certainty, be rejected. The curve was obtained by only 4 samples, containing—of phosphorus

·550 H.
·301 F.
·050 L.
·021 G.

Should this system come into general use, it is very probable that some such form of apparatus as shown at *fig.* 2390 on the drawings will be found the best, because greater quantities of the material under examination can be brought under the action of the spark. Iron, in the form of filings, gives a very fine spectrum in this way. Wishing to try on samples of iron containing larger quantities of phosphorus, the author asked Mr. EDWARD RILEY to send him some of those from which he had made analyses; that gentleman kindly forwarded him five samples, ranging from 3·334 per cent. to ·027; a sample containing ·081 was tried, and fell into its place in the curve in a very satisfactory way. The sample containing 3·334 was also examined, and it was found that when such large quantities are present, other lines must be taken into account—the line 181·6½ is wholly absorbed by the hydrogen, with 6 cub. in. of carbonic acid; it came out as a great broad band, nearly as broad as that of the phosphorus. Other lines came out which do not appear in iron, containing ·550; these lines are nearer the blue. *Fig.* 2394 is a modification of Becquerel tube, which is used generally for the examination of solutions. A great objection has been found to using them as open tubes; with a fluid quantities of it are scattered by the action of the spark, to the great injury of the slit of the spectroscope and the eyes of the operator. The same objection holds good with a powder. A plain glass would probably be a better form of apparatus than any before mentioned. It would be preferable to pass the platinum electrode through a glass tube so as to insulate it from the stopper, because the deflagration from either a fluid or a powder so coats the glass and the face of the stopper that the current passes that way; the glass rod, should it also become coated, is easily cleaned by drawing it up through the cork and wiping the coating from it, and ensuring that the circuit can be made only by passing from the platinum electrode to the fluid or the powder. The subject of such large quantities as 2, 3, or more per cent., requires further experiment.'

In continuation of this subject, it may be mentioned that in 1873 Mr. NORMAN LOCKYER and Mr. W. C. ROBERTS, the Chemist of the Mint, communicated to the Royal Society a paper 'On the Quantitative Analysis of Certain Alloys by means of the Spectroscope,' an abstract of which paper appeared in the *Proceedings of the Royal Society*, vol. xxi., No. 147, p. 507.

The authors showed that the spectroscope might be employed to detect minute differences in the composition of certain alloys, and described their researches which were instituted to ascertain the degree of accuracy to which the method is capable. They say the image of an electric spark passing between the unknown alloy, and a fixed electrode being thrown by means of a lens on the slit of the spectroscope, the phenomena observed were found to vary with the composition of the alloys, and further, by arranging them together with known check-pieces on a suitable stand, and bringing them in turn under the fixed electrode, the composition of the unknown alloys was determined with the known check-pieces.

The shape of the electrode ultimately adopted was that of flat cone-shaped pieces, which were held in their places by suitable metallic clips. Special attention was then directed to the adjustment of the length of the spark, which was found to materially influence the phenomena. The method adopted consisted in placing the variable electrode in the field of a fixed microscope, having a 3 or 4 inch objective, and adjusting the summit of this electrode to coincide with the spider lines of the eye-piece.

After a series of experiments on alloys of zinc and cadmium of various compositions, more extended trials were made with the gold-copper alloy employed in coinage, which was peculiarly suited to these researches in consequence of the known method of assay having been brought to so high a state of perfection (the composition being determined with accuracy to the $\frac{1}{10000}$th part of the original assay-piece of about 7 grains), and from the fact that reliance can be placed on its homogeneity.

The chief practical advantage which appeared to flow from this inquiry was that, if it were possible to replace the parting assay by the spectroscopical method, a great saving of time in ascertaining the value of gold bullion would be effected.

These researches have a direct bearing on the use of the spectroscope for the analysis of all the varieties of iron and steel, or any alloys of those metals. The researches of Mr. NORMAN LOCKYER include a statement of 'The Experiments made on a possible Quantitative Spectrum Analysis.'

These should be studied in connection with the paper in the *Philosophical Transactions*, vol. clxiii., part i., p. 253, 'Researches in Spectrum Analysis in connection with the Spectrum of the Sun.'

STEELING IRON. Mr. J. Barnett has recently patented a process for effecting this. The invention relates to the preparation and application of material for the purification of iron while it is melted for the purpose of puddling (the said material serving also to provide fettling for the furnace in which the process is carried on), and also to the preparation and application of a material for hardening iron and steeling its surface. The inventor makes a saturated solution of salt, and pours a quantity of such solution, say one or two ordinary bucketfuls, into the puddling furnace, in which an amount of cinder may also be deposited. He also saturates the purple ore used as fettling, with the saline solution, using such purple ore in the ordinary way, as fettling in conjunction with 'tap,' pottery mine, &c. Between each heat a bucketful of the saline solution is poured into the furnace to set the cinder with, and to further protect the bottom plate. Any earthy or carbonaceous matter, granulated or otherwise, is saturated with the saline solution, and burnt down at a slow heat into a granulated form, which material is mixed either with the solution of salt or with water, and thrown on the bottom and at the sides of puddling furnaces, both as fettling and as a purifier of the iron made. Vegetable or any earthy matter, saturated with the solution, granulated or otherwise, is thrown into the puddling furnace, either before charging with the pig iron or as the metal melts; the same material serving as fettling, and also as a purifier of iron by means of equally distributing salt, or salt and carbon, throughout the metal while the puddling process is in force. The patentee, for the purpose of cleansing, hardening, and steeling the surface of manufactured iron, takes carbon, and boils it down in the above saline solution until the moisture evaporates, or carbon is steeped in saline solution, and burnt into a granulated form, saturated with any oleaginous matter, and formed into paste, which is spread over the iron to be acted upon, and the latter is then subjected to the action of heat until the steeling process becomes complete.

IRON AND STEEL, CORROSION OF, PREVENTED. A considerable amount of attention has been drawn to a method, announced by Professor Barff, as effectually preventing the corrosion of iron and steel. The following is an abstract of a paper read by the discoverer at the United Service Institution:—

Experiments, he said, were made in an iron tube, 10 in. long by 2 in. diameter, the two ends being closed with iron caps, and into it two iron pipes were fastened, one for the passage in of steam, and the other for the outlet of hydrogen. Into the small chamber, pieces of iron were put, and the chamber itself was placed in an ordinary furnace, and heated to a red heat, generated steam being then passed into it. The iron was coated in a short time with thick oxide. Hydrogen gas escaped from the exit tube. The black oxide could sometimes be dusted off; at other times it seemed coherent, but on exposure to the air it was thrown off in powder or flakes. On one occasion, on taking a piece of iron out of the chamber, Professor Barff noticed a brownish red tint on it, and at once concluded that some of the red oxide of iron was produced on the surface and mixed with the black oxide. The idea struck him that the presence of moisture in steam formed the red oxide, which was afterwards reduced to metallic iron by the hydrogen, and that the reduced iron was converted by steam into black oxide. Experiments confirmed this surmise. He had a coil of iron pipe made and attached to the iron chamber between it and the ingress tube, and so constructed that it could be put into the chamber with the furnace. The steam, therefore, passed slowly through the heated coil of iron pipe before coming into contact with the iron to be acted upon, and nearly the first experiment showed that a hard coherent coating, adhering to the iron, could be produced. The two conditions necessary to success are the exclusion of atmospheric air and the perfect dryness of the steam. The lateral spreading of rust already present is prevented by this system of oxidation, and a perfectly pure coating of the black oxide of iron is formed, which completely protects the metal from the action of either air or moisture.

The oxide is harder than the original iron, and adheres to it even more firmly than the particles of iron adhere to each other, so that there is a gain not only in chemical, but also in mechanical, resistance. If the operating chamber is heated only to 500° Fahr., and the exposure is continued for only five hours, a surface is obtained which will resist emery paper for a considerable time, and which will not rust within doors, or after any moderate degree of exposure to moisture. If the oxidising process is conducted at 1,200° Fahr., and continued for six or seven hours, the surface will resist a rasp, and will bear any amount of exposure to weather. The oxidation does not affect the appearance of the surface in any other way than by turning it black. A rough forging retains its roughness, and a turned or polished surface retains its smoothness. If there should be any flaw in the coating, or if the black oxide is

designedly removed from part of the surface, the common oxidation will occur where the iron is thus left unprotected. But such oxidation is strictly limited to the unprotected portion, and has not the smallest tendency either to spread laterally under the black oxide or to detach this from the subjacent parts.

IRON AND OTHER MAGNETIC METALS. *The molecular changes which accompany its magnetisation.*—The following—portions of an admirable paper—has been placed at my disposal by Professor W. F. Barrett. I have preferred giving it in the author's own words:—

'The magnetisation of iron is accompanied by certain molecular changes in the metal which are well known to physicists. Further inquiry in this direction seems to be needed as presenting one avenue of approach to a better insight of what may be termed the "molecular architecture" of a magnet.

'The wonderful transition of iron from an ordinary to a magnetised condition makes no alteration in the appearance, the temperature, the weight, or the total bulk of the iron; but it is associated with the changes alluded to, which are briefly as follows:—

'1st. The act of magnetisation causes a slight increase in the *length*, and a corresponding diminution of the breadth of an iron bar—a fact discovered by Mr. Joule in 1842, confirming the previous observations of MM. Gay-Lussac and Wertheim, that there was no alteration in the total volume of the iron. This elongation, however, does not occur when the iron is submitted to a definite longitudinal strain; and when the strain is still greater, the iron invariably *shortens* when magnetised.

'2nd. A *sound* is emitted by the iron on magnetisation and again on demagnetisation. This was revealed by Mr. Page in 1837, and studied by many physicists subsequently. In iron wires the sound or clink seems composed of two distinct noises, one of which intensifies by a moderate strain, but is destroyed and the whole sound enfeebled by a still higher strain.

'3rd. M. Wiedemann has proved that an iron wire hung in the centre of a helix, and twisted, is more or less *untwisted* when a current traverses the helix and magnetises the wire. M. Matteucci has shown that twisting a magnet lessens its force, but stretching a magnet slightly adds to its power; and, according to M. Guillemin, a strip of iron bent by its own weight is partly strengthened by magnetisation.

'4th. The *conduction of heat* in magnetised iron is greater *across* than along the magnetic axis—a fact discovered by Dr. Maggi, and enlarged by Sir W. Thomson, who has shown that its precise analogue is to be found in the conduction of *electricity* in magnetised iron and nickel.

'5th. A bar of wrought iron is more easily magnetised in the direction of its fibre; and steel once magnetised in a given direction and then demagnetised is more readily magnetised in its first direction than in any other—a fact first pointed out by M. Marianni, and recently again observed by M. Jamin.

'Lastly, it is well known that mechanical blows aid the assumption of magnetic power in steel, but tend to lessen and can even destroy it when assumed; and the same also is true of heat, which no doubt acts in a similar way, viz. by lessening the cohesion of the particles of steel.

'All these facts may be embraced under the assumption first made by M. De la Rive, that magnetisation is expressed by a definite movement, or a marshalling of the molecules of iron—the placing, as Dr. Tyndall puts it, of their longest dimensions end to end. Now iron is not the only magnetic body. Nickel and cobalt share the magnetic properties of iron to a very high degree; and to a much less extent the metals chromium and manganese are also magnetic. If, then, magnetisation is an act associated with an altered structure of iron, we should expect to find a certain correspondence to iron in the properties of the other magnetic metals.

'I was anxious to try further whether the molecular disturbances found on magnetising iron were also exhibited by nickel and cobalt. One would of course expect to find analogous changes in these bodies, but I am unaware that they have hitherto been examined.

'Messrs. Johnson and Matthey very kindly lent me an extremely fine bar of nickel and one of cobalt. Both bars are cylindrical, a little over 9 in. long and 1 in. in diameter. Though as pure specimens as they can be rendered commercially, the cobalt I find contains a very appreciable amount of iron; the removal of which body, as chemists well know, is a matter of the utmost difficulty.

'The relative magnetic powers of these two bars deserves a moment's consideration. Nickel is invariably ranked above cobalt in the scale of magnetic metals, Faraday and others placing it next to soft iron. But the bar of nickel I have used, when submitted to the same magnetising current as the cobalt bar, exhibits far less portative force than the cobalt. It is remarkable that the iron impurity contained in the cobalt is able to produce so powerful an influence. The nickel, like other spe-

cimens I have met with, has very slight retentive power when magnetised, whereas the cobalt has a high degree of coercive force.

'Enclosing either of the bars within a helix of wire, a sound was emitted as soon as an interrupted current traversed the helix. The sound with *cobalt* was far the more powerful of the two, and was even more pronounced and more metallic than with a corresponding bar of iron. This fact, I believe, has not been noticed before. It is easy to obtain these sounds by merely using the coil of an electromagnet and drawing the terminal of the battery wire over a coarse file in a distant room.

'In order to examine whether the metals lengthened by magnetisation, I had a special apparatus made for me by Messrs. Yeates, of Dublin and London. The instrument is a modification of the arrangement used by Dr. Tyndall, and described by him in his *Researches on Diamagnetism*, p. 240. Instead of being mounted vertically, the iron bar in my instrument is placed horizontally within the coils of a powerful electromagnet. One end of the bar is rigidly pressed by the end of a micrometer screw, which is mounted on a sliding brass support that can be adjusted to any length that the bar under experiment may be. The other end of the bar presses against a system of levers, by which the least motion of the bar is largely multiplied. On an axle moved by the last lever a mirror is fixed; and upon this a beam of light is thrown, the reflected image being received on a distant scale.

'I have now to allude to the deportment of iron when raised to a high temperature. Mr. Faraday has shown, in the last page of his *Experimental Researches*, that a moderate degree of heat does not alter the magnetic capacity of iron, but diminishes the magnetic force of nickel and *increases* that of cobalt. At a greater elevation of temperature it is well known that nickel first loses its ordinary magnetic character, then iron, and finally cobalt. But Mr. Faraday has also stated (§§ 2343–2347) that though the magnetism of iron, nickel, and cobalt, as ordinarily exhibited, disappears at a high temperature, yet a feeble magnetic state remains, however exalted the temperature may be.

'Some time ago several specimens of very tough fibrous iron were shown to me that had been obtained directly from cast iron by bringing high magnetic power to bear upon the latter metal when in a molten state. The process, which was patented, was thus popularly described by the *Athenæum* for April 20, 1867:—"The experiment has been tried at one of the leading iron-works in Sheffield, and with complete success. The mode of operation, as roughly described, is to place a fixed electromagnet opposite an opening in the side of the furnace, to excite the magnet by means of a Smee's battery, so that the magnetism thus evoked may act upon the molten metal. The effect is surprising; the metal appears to bubble and boil, the melting is expedited, which economises fuel; and the quality of iron is so much improved, that for toughness and hardness it can hardly be equalled. It appears that some, if not all, of the impurities which remain after the ordinary process are eliminated by the use of magnetism." The scheme is so opposed to the ordinary views regarding the inertness of molten iron to magnetism, that any physicist must be naturally incredulous at this report, and would expect the patent to meet with the oblivion it has received. Nevertheless, is it not possible, from Mr. Faraday's experiments, that some magnetic effect, not of translation but of direction, may be impressed on the molecules of molten iron?

'The *resumption* of magnetic power by iron after being raised to bright incandescence is thus described by Mr. Faraday:—"The intensity of the force did not appear to increase until the temperature arrived near a certain point; and then, as the heat continued to diminish, the iron *rapidly*, but not instantaneously, acquired its high magnetic power, at which time it could not be kept from the magnet, but flew to it, bending the suspending wire, and trembling as it were with magnetic energy as it adhered by one end to the core." (*Exp. Res.* § 2345).

'Approximately at that temperature wherein a cooling iron wire resumes its magnetic state, a profound change occurs in the physical condition of the metal. A momentary dilatation of the iron takes place; its thermoelectric position is reversed; a sound is emitted; and a sudden reheating, or "after-glow," is seen to diffuse itself throughout the metal just before it ceases to be incandescent; and its electric and thermal resistance at this point appears to undergo a change, though this has yet to be strictly determined.'

Magnetic Metals, their Relationship.—The remarkable similarity in the chemical and physical properties of the magnetic metals has no doubt often attracted attention; but no definite collation of these properties has ever been made until it was undertaken by Professor Barrett. The extraordinary homology these metals are thus seen to exhibit, furnishes instructive evidence concerning the molecular state of a magnet.

By magnetic metals those metals which possess magnetic properties under ordinary circumstances—namely, iron, nickel, and cobalt—are intended.

First we will compare their physical characteristics. The *specific gravity* of the thirty-eight known metals ranges from lithium 0·59, to platinum 21·5, a difference of nearly 21; whereas the specific gravity of iron is 7·8, nickel 8·3, and cobalt 8·5, an extreme difference of only 0·7. The *specific heat* of these three metals is also nearly identical; and their *atomic heat* is the same. Their *conductivity for sound* is almost absolutely the same; and so far as their heat and electric conductivity have been determined they are also alike. Their *dilatation by heat* is the same, and so also is the amount they lengthen by mechanical strain. They belong to the same system of *crystallisation*, namely, the monometric, though too little is known on this point. The enormous *cohesive power* of iron, nickel, and cobalt in the solid state signalises these substances as the most *tenacious* of metals. To overcome this cohesion a very high and somewhat similar temperature is required, and their *melting-point* is only exceeded by the platinum group of metals. Their refractory character renders them not volatile even at the temperature of the hottest furnace. When, however, they are volatilised by means of the electric spark, their incandescent vapours yield a *spectrum* which has a close and curious resemblance. This teaches us that the molecules of these bodies, freed from the thrall of cohesion, vibrate in periods which are closely akin.

A comparison of the *chemical* properties of the same metals furnishes a similar result. The ratio of the combining weight of the metallic elements ranges from lithium 7, to bismuth as 210, or a difference of 203. When we compare the magnetic metals, we find the combining weight of iron is 56·0, nickel 58·5, and cobalt 58·5, or a difference of only 2·5. Chemists class these three metals in the same group from the similarity of their chemical behaviour, and also the identity of their combining energy or atomicity.

In strong nitric acid, iron becomes endowed with a so-called passive condition, not acted upon, as it is in the dilute acid. Likewise nickel is capable of assuming a passive state in strong nitric acid. Cobalt, it is true, was violently acted upon under similar circumstances; but that was due to the fact that the cobalt contained iron largely, and so an electrolytic action was probably set up.

A series of very similar chemical compounds are formed by these metals, mostly characterised by the brilliancy of their colour. The protosalts of iron are generally bluish green, of nickel emerald green, and of cobalt of a rose-colour. It is moreover a well known fact that this rose-colour of certain cobalt salts passes into a *bright green* when they are warmed. Now, when the metal cobalt is moderately heated it *increases* in magnetic power, thus differing from its congeners, iron and nickel, which are in their maximum magnetic condition at the ordinary temperature, and at ordinary temperatures present the green-coloured salts.

What has been said concerning the likeness of iron, nickel, and cobalt, in many respects holds true of *manganese* and *chromium*, also feebly magnetic metals. Placed in the same group with the former metals chemically, they are physically characterised by their extraordinary tenacity and difficult fusibility. Manganese has lately been used to replace nickel in the alloy of German silver, and with excellent results. It is also worthy of note that the compounds of these five metals are conspicuous by the brilliancy of their colours, all their salts exerting a selective absorption on light, and their oxides dissolved in borax yielding well-known and characteristic tints—a comparatively rare feature outside this group.

Further, it is well known that the ores of cobalt and nickel are almost invariably found associated in the earth and with difficulty separated. It is also noteworthy that both nickel and cobalt are usually present in meteoric iron—the average composition of meteorites being 90 per cent. of iron, 8 per cent. of nickel, and 0·5 per cent. of cobalt, curiously enough often with a trace of the other feebly magnetic metals, manganese and chromium.

This uniform coincidence in the properties of iron, nickel, and cobalt, suggests the practical inference that nickel and cobalt might be obtained in a malleable and ductile condition when submitted to a process similar to that by which wrought iron is produced. At present it is impossible to procure nickel or cobalt wire, though there seems no reason why they could not be made if a demand arose. Nickel wire would probably prove very useful from its high tenacity and comparative freedom from oxidation.

The following table sums up some of the most striking points of contact in the physical properties of the three magnetic metals *par excellence*:—

Table showing the Physical Relationship of the Magnetic Metals.

Substance	Density. Water =1	Atomic Weight. H=1	Specific heat. Water =1	Atomic Heat	Dilatation by Heat[1]	Dilatation by Strain[1]	Conductivity for Heat Silver =1	Conductivity for Sound.[1] Air=1	Tenacity and Melting-point
Iron . . .	7·8	56·0	0·1138	6·38	·0356	·0687	·168	15·3	Very high
Nickel . . .	8·3	58·0	0·1091	6·33	·0486	·1304	·131	14·9	"
Cobalt . . .	8·5	58·5	0·1070	6·26	·0091	·0436	·172	14·7	"

From this table it is evident that the molecular constitution of the magnetic metals is essentially alike, largely differing from bodies which are not magnetic. And this being so, further evidence is afforded that the evolution of ordinary magnetic phenomena is in some way associated with the peculiar and similar structure of the molecules of iron, nickel, and cobalt.

W. F. B.

IRON MANUFACTURE. Great Britain in 1875 and 1876.

Iron Ore.—The total quantity of iron ore raised in the United Kingdom, as shown in the preceding returns, amounted in 1875 to 15,821,060 tons.

	1875 Tons	1876 Tons
Foreign ores imported	458,603	672,235
Purple ores from *pyrites* imported .	280,000	292,000
Total quantity of iron ore returned as smelted in Great Britain	16,559,763	17,290,856

Number of Furnaces in Blast.

	1875	1876
England	424	392½
Wales	86	73
Scotland	119	119
Total	629	584½

Pig Iron produced and Coal returned as used in its Manufacture in the years 1875 and 1876.

	1875		1876	
	Pig Iron	Coal used	Pig Iron	Coal used
	Tons	Tons	Tons	Tons
England	4,718,554	11,391,646	4,664,153	10,871,706
Wales	596,908	1,304,128	788,844	1,676,675
Scotland	1,050,000	2,950,000	1,103,000	3,050,000
Total . .	6,365,462	15,645,774	6,555,997	15,598,381

When coke has been given in the return it has been computed as coal.

[1] For the figures in this column I am indebted to a paper by M. A. Masson, in the *Annales de Chimie et de Physique* for 1858. In the heat column the decimal would, of course, have to be moved four places to the left to express the coefficient for 1° C. The dilatation by strain was of one metre of the body under a weight equal to itself.

Summary of Pig Iron produced in 1875 and 1876.

Counties	1875				1876			
	No. of Ironworks active	No. of Furnaces built in District	No. of Furnaces in Blast	Tons of Pig Iron made	No. of Ironworks active	No. of Furnaces built in District	No. of Furnaces in Blast	Tons of Pig Iron made
				Tons				Tons
ENGLAND:—								
Northumberland	2	4	2	21,870	1	4	1	423,172
Durham	16	70	63	786,206	13	63	34½	1,271,013
Yorkshire, North Riding	17	85	73	1,240,243	19	86	75	235,431
" West Riding	17	50	38	267,153	16	49	34	300,719
Derbyshire	13	51	38	272,085	12	54	35	552,951
Lancashire	9	30	11	[illegible]780	9	47	30	43[illegible],867
Cumberland	11	51	31½	656,117	12	49	27	1[illegible]9,711
Shropshire	11	26	20	130,996	10	24	16	213,[illegible]
North Staffordshire	8	39	26	241,386	8	37	24	465,91[illegible]
South "	63	155	76½	470,540	41	144	64	84,91[illegible]
Northamptonshire	7	13	12	80,859	7	20	11	125,108
Lincolnshire	5	21	14	111,693	6	21	16	28,106
Gloucestershire	3	10	6	27,000	3	10	8	
Wiltshire	1	4	3	32,731	1	7	2	20,479
Hampshire	1	1	—		—	1	—	
Somersetshire	1	1	1		1	1	1	
Total	178	626	434	4,712,634	160	623	393½	4,064,153
WALES:—								
North Wales.								
Denbighshire	3	9	0	53,000	2	9	3	32,723
Flintshire	1	2	1		1	2	1	
South Wales.								
Anthracite Furnaces	2	13	7	30,869	3	13	6	30,421
Bituminous coal districts — Glamorganshire	14	78	35	240,067	9	59	28	321,724
Bituminous coal districts — Monmouthshire	13	63	37	262,253	10	63	33	413,946
Total of North and South Wales	33	164	86	606,308	24	145	73	788,811
SCOTLAND:—								
Ayrshire	7	43	33	338,164	7	42	33	300,971
Lanarkshire	13	94	74	631,493	13	93	78	660,078
Fifeshire	2	6	3	43,741	2	6	0	82,600
Linlithgowshire	2	9	5		3	9	6	
Stirlingshire	3	7	5	16,600	1	6	3	
Argyllshire					1	1	1	
Total	26	130	118	1,050,000	26	136	119	1,1[illegible],000

The production of pig iron in the United Kingdom of Great Britain and Ireland from 1855 to 1876 is given from the returns made to the *Mining Record* office:—

Year	Gross Tons	Year	Gross Tons
1855	3,218,151	1866	4,523,897
1856	3,586,377	1867	4,761,023
1857	3,659,477	1868	4,970,206
1858	3,456,064	1869	5,445,757
1859	3,712,904	1870	5,963,515
1860	3,826,752	1871	6,627,179
1861	3,712,390	1872	6,741,929
1862	3,943,469	1873	6,566,451
1863	4,510,040	1874	5,991,408
1864	4,767,901	1875	6,365,462
1865	4,819,254	1876	6,555,997

The British Iron Export Trade for the Calendar Years 1873 *to* 1875. *From the Board of Trade Returns.*

Principal Articles only to all Countries	Quantities in Tons		
	1873	1874	1875
Pig iron	1,142,065	776,116	951,475
Bar, angle, bolt, and rod	286,845	258,953	276,686
Railroad of all sorts	785,014	782,665	546,517
Wire of iron and steel (except telegraph), galvanised or not	29,445	36,692	43,077
Hoops, sheets, boiler and armour plates	201,570	163,430	204,480
Tinned plates	120,638	122,960	138,663
Cast or wrought, and all other manufactures (except ordnance) unenumerated	282,000	257,069	240,011
Iron, old, for remanufacture	60,339	43,141	20,994
Steel, unwrought	39,418	31,440	29,733
Manufactures of steel, or steel and iron combined	10,479	10,056	11,044
Total of iron and steel	2,957,813	2,487,622	2,465,640
To the United States (included in the above).			
Pig iron	102,624	43,563	49,868
Bar, angle, bolt, and rod	22,676	4,729	3,264
Railroad of all sorts	186,300	11,267	6,093
Hoops, sheets, boiler and armour plates	18,272	8,381	11,023
Cast or wrought, unenumerated	22,571	20,058	7,818
Steel, unwrought	19,339	13,562	10,681
Total	371,782	101,565	89,617

Principal Articles only to all Countries	Values in Pounds sterling		
	1873	1874	1875
Pig iron	7,118,037	3,673,734	3,474,621
Bar, angle, bolt, and rod	3,755,980	3,054,547	2,729,833
Railroad of all sorts	10,418,852	9,638,236	5,450,898
Wire of iron and steel (except telegraph), galvanised or not	692,470	769,927	781,073
Hoops, sheets, boiler and armour plates	3,722,889	2,975,409	3,303,121
Tinned plates	3,953,012	3,714,810	3,691,382
Cast or wrought, and all other manufactures (except ordnance) unenumerated	5,478,759	5,122,588	4,312,615
Iron, old, for remanufacture	309,522	245,381	100,012
Steel, unwrought	1,462,857	1,203,710	1,070,446
Manufactures of steel, or steel and iron combined	723,831	791,505	828,420
Total of iron and steel	37,731,239	31,190,256	25,781,421
Steam engines	2,927,617	3,255,083	2,620,491
Other machinery and millwork	7,092,812	6,535,229	6,478,222
To the United States (included in the above).			
Pig iron	693,694	213,979	191,141
Bar, angle, bolt, and rod	308,226	74,064	55,698
Railroad of all sorts	2,434,135	147,970	65,891
Hoops, sheets, boiler and armour plates	303,581	131,358	138,553
Cast or wrought, unenumerated	443,287	352,022	143,668
Steel, unwrought	707,635	503,058	382,667
Total	4,890,661	1,422,481	977,608

Export iron and steel in 1876:—

	Tons	Value £
Pig iron	905,029	2,344,834
Bar, angle, bolt, and rod	227,714	1,913,966
Railroad of all sorts	413,656	3,706,261
Wire of iron and steel (not telegraph)	41,959	730,099
Hoops, sheets, boiler and armour plates	192,287	2,859,743
Tin plates	132,397	2,898,027
Cast or wrought, and all other manufactures (except ordnance) unenumerated	243,432	4,013,372
Old, for remanufacture	22,814	97,166
Manufactures of steel, or of steel and iron combined	10,285	758,253
Total of iron and steel	2,218,568	20,730,679

The Board of Trade, in accordance with the wish of the iron and steel trade, endeavoured in 1876 to distinguish the quantities of iron and steel rails exported from the United Kingdom. The following account, the Board of Trade says, 'is published with some hesitation, as it is not considered sufficiently trustworthy to indicate the export trade under two separate heads; the total quantity of rails, however, may be accepted as correct:'—

Year ended December 31, 1876.

	Quantities		Values	
	Iron Rails	Steel Rails	Iron Rails	Steel Rails
	Tons	Tons	£	£
Russia	12,625	66,029	109,221	633,128
Sweden and Norway	14,445	3,928	246,548	36,632
Germany	303	12,043	2,140	121,469
Spain	10,723	6,279	75,605	55,506
Italy	16,019	3,027	108,993	10,520
United States	161	—	1,422	—
Brazil	16,020	4,096	114,112	36,843
Chili	956	2,068	6,724	19,277
British North America	21,830	36,247	161,799	336,006
British India	30,404	10,330	225,316	88,825
Australia	13,946	10,442	104,074	105,580
Other Countries	33,599	19,545	253,960	183,068
Total	190,054	173,754	1,409,843	1,636,552
Total of rails	363,808			

AUSTRIA.—This is essentially connected with the development of the railway system in that country. From 1866 the development was as follows:—

	Austrian Miles
1866	35·091
1867	39·967
1868	97·389
1869	113·940
1870	211·246
1871	260·636
1872	280·060
1873	224·611
1874	66·598
1875	90·730
	1440·597
1876	95·560

The period comprised between the years 1870 and 1873 was that of the greatest relative activity in railway construction. In these four years 1,000 Austrian miles of railway were laid, or 250 miles a year. Before and after this period the rate of

construction varied from 35 to 114 miles a year. Taking the common estimate of 10,000 cwt. per mile as the basis of our calculation of the quantity of new rails required, we find the yearly totals of consumption of iron to be as follows:—

	Cwt.		Cwt.
1866	350,910	1872	2,806,690
1867	399,870	1873	2,246,110
1868	973,800	1874	665,980
1869	1,139,400	1875	907,300
1870	2,112,460	1876	955,500
1871	2,806,360		

The imports and exports of rails are given as follows in the Austrian returns:—

Years	Imports	Exports	Excess	
			Imports	Exports
	Cwt.	Cwt.	Cwt.	Cwt.
1866	3,306	4,982	—	1,676
1867	508	2,179	—	1,671
1868	1,084,375	812	1,083,563	—
1869	2,298,632	1,872	2,296,760	—
1870	2,336,260	1,165	2,335,095	—
1871	2,026,046	4,409	2,021,637	—
1872	1,316,782	4,752	1,312,030	—
1873	1,049,633	14,251	1,035,382	—
1874	202,200	155,911	46,289	—
1875	26,900	215,488	—	188,588

The Vienna correspondent of the *Economist* gives some interesting figures with reference to the growth of iron production in France and Germany, which we subjoin:—

	France	Germany
	Cwt.	Cwt.
1859 to 1864	13,334,134	13,309,399
1865 to 1869	15,630,362	20,372,009
1870 to 1874	18,295,832	33,714,417

The writer remarks that the enormous progress in the German ironworks in the last period is in great part due to Alsace and Lorraine having been annexed to Germany, which causes a great loss to France and a corresponding gain to Germany.

STYRIA, &c. *Production of Charcoal Iron in.*

	Years	Styria	Carinthia	Carniola	Austrian Tyrol, Salzburg	Total
		Tons	Tons	Tons	Tons	Tons
Forge pig . . .	1851	47,728	31,693	3,288	7,153	89,862
Foundry pig . .	,,	1,706	883	331	919	3,839
Number of furnaces	,,	32	22	11	12	77
Forge pig . . .	1861	71,009	41,500	6,051	7,821	127,431
Foundry pig . .	,,	1,544	756	319	797	3,416
Number of furnaces	,,	32	21	11	10	74
Forge pig . . .	1871	121,858	63,191	3,539	6,785	195,[illegible]81
Foundry pig . .	,,	5,267	1,915	316	2,056	9,554
Number of furnaces .	,,	31	17	7	7	62
Thus by furnace and by year the production has been	1851	1,500	1,500	338	674	—
	1861	2,340	2,340	580	891	—
	1871	4,100	3,820	552	1,2[illegible]	—

In 1873 the total production of all those districts was 237,[illegible]. This was the highest production ever attained; in 1874 the production fell off nearly 20,000 tons.

BELGIUM. *Production of Iron and Steel, 1875.*

	Brabant	Hainault	Namur	Liège	Luxembourg	Total of the Kingdom
Furnaces in blast	7	161	46	92	11	[illegible]
Workmen employed	1,330	11,808	1,836	8,410	422	23,814
Production—cast iron (tons)¹	3,000	237,127	47,061	294,214	22,583	[illegible]
Value in francs	692,230	60,310,404	8,966,248	21,172,909	2,603,000	28,871,[illegible]31
Production—pig iron (tons)¹	22,760	255,100	35,778	159,991	233	[illegible]
Value in francs	5,057,000	52,594,093	7,213,390	32,476,081	146,500	97,[illegible]21,030
Steel works	—	—	—	3	—	3
Workmen employed	—	—	—	1,672	—	1,672
Production in tons¹	—	—	—	47,200	—	47,200
Value in francs	—	—	—	14,124,000	—	14,124,000

FRANCE. *Table of Production of Blast Furnaces in 1875*

Departments	Smelted with Charcoal	Smelted with two kinds of Fuel	Smelted with Coal or Coke	Total
	Metrical Quintals²	Metrical Quintals	Metrical Quintals	Metrical Quintals
Allier	—	—	924,080	924,080
Ardèche	—	—	790,883	790,883
Ardennes	31,950	—	114,000	145,950
Ariège	—	27,000	115,711	142,711
Aube	—	12,172	—	12,172
Aveyron	—	—	379,370	379,370
Bouches-du-Rhône	—	—	315,955	315,955
Cher	56,450	110,036	117,800	284,286
Corse	92,600	—	—	92,600
Côte-d'Or	49,900	—	83,000	132,900
Côtes-du-Nord	6,025	10,718	—	16,743
Dordogne	67,268	—	—	67,268
Doubs	19,330	—	—	19,330
Eure	—	—	3,268	3,268
Eure-et-Loir	—	—	11,237	11,237
Gard	—	—	639,036	639,036
Gironde	47,260	—	—	47,260
Ille-et-Vilaine	25,145	—	—	25,145
Indre	40,540	—	—	40,540
Isère	15,231	—	180,480	195,711
Jura	—	—	220,084	220,084
Landes	160,630	—	—	160,630
Loire	—	—	505,606	505,606
Loire-Inférieure	5,800	—	—	5,800
Lot-et-Garonne	8,000	—	140,000	148,000
Marne	—	—	25,475	25,475
Marne (Haute)	216,192	387,871	229,685	833,748
Mayenne	—	21,030	—	21,030
Meurthe-et-Moselle	30,482	—	2,958,017	2,988,499
Meuse	58,400	31,000	207,000	296,800
Morbihan	39,600	—	—	39,600
Nord	—	—	1,432,347	1,432,347
Orne	—	—	8,200	8,200
Pas-de-Calais	—	—	557,550	557,550
Pyrénées-Orientales	85,000	—	—	85,000
Rhône	—	—	627,933	627,933
Saône (Haute)	146,990	—	—	146,990
Saône-et-Loire	—	—	1,723,007	1,723,007
Sarthe	—	17,829	—	17,829
Savoie	8,670	—	—	8,670
Savoie (Haute)	1,950	—	—	1,950
Tarn-et-Garonne	5,000	—	—	5,000
Vienne	—	—	10,900	10,900
Total	1,218,813	617,746	12,320,724	14,157,283

¹ Metrical ton of 1,000 kilograms, or 19 cwt. 2 qrs. 20 lb. 10 oz.

² Of 2[illegible] lb.

Smelted with charcoal . . .	110,776	English tons of 2,240 lb.
" " and coke	60,671	" "
" coke and coal .	1,210,071	" "
Total .	1,381,518	

The production of merchant iron in France in 1875:—

From charcoal iron	232,802	metrical quintals of 220 lb.
From charcoal and coke . .	212,651	" "
From coke or coal—rails .	1,189,589	" "
Other than rails . . .	5,919,380	" "
Total	7,108,969 = 698,202 English tons.	

The production of sheet iron in France in 1875:—

Sheets produced from Iron made with—

Charcoal	128,515	metrical quintals of 220 lb.
Charcoal and coke or coal	94,278	" "
Coke or coal . . .	926,519	" "
Total . . .	1,149,312 = 112,432 English tons.	

Total Production of Steel in France in 1875.

Departments	Forge Steel	Puddled Steel	BESSEMER and MARTIN'S steel	Steel by Cementation	Total production of these	Cast Steel
	Metrical Quintals of 220 lb.	Metrical Quintals of 220 lb.	Metrical Quintals of 220 lb.	Metrical Quintals of 220 lb.	Metrical Quintals of 220 lb.	Metrical Quintals of 220 lb.
Allier . .	—	—	256,000	—	256,000	—
Ardennes	200	—	—	—	200	500
Ariège . .	350	22,577	—	880	23,807	250
Charente . .	—	—	8,000	—	8,000	—
Côte-d'Or	120	—	—	—	120	—
Côtes-du-Nord .	—	360	—	26	386	261
Finistère . .	—	—	—	—	—	191
Gard . .	—	—	277,016	—	277,016	—
Garonne (Haute)	—	—	—	7,200	7,200	—
Isère . .	2,000	45,800	7,200	1,200	56,200	1,600
Loire . .	—	95,903	707,396	9,497	812,796	49,070
Meurthe-et-Moselle . .	—	10,200	—	—	10,200	—
Nièvre . .	—	3,743	107,746	—	111,489	6,26
Nord . .	—	—	164,669	—	164,669	—
Rhône . .	—	—	170,538	—	170,538	—
Saône (Haute) .	—	—	500	—	500	430
Saône-et-Loire .	—	—	623,261	—	623,261	—
Seine . .	—	—	5,850	—	5,850	—
Seine-et-Oise .	—	—	—	—	—	1,153
Tarn . .	—	—	—	1,142	1,142	1,680
Total . .	2,670	178,583	2,314,767	20,445	2,516,374	61,431

The total quantity of forged and puddled steel, of BESSEMER and MARTIN'S steel, in English tons	247,147
Cast steel	6,033
	253,180

RUSSIA.—Mr. A. C. SHERRIFF, M.P., writes from Moscow, giving some particulars of the charcoal iron manufacture at Vyksa, about 700 miles from St. Petersburg and 300 from Moscow in a SSE. direction. The forests, he states, are composed chiefly

of pine and birch, and the ore is so close to the surface that it is worked in a very primitive way; when it is calcined it averages about 42 per cent. of metallic iron.

The blast furnaces have to be placed at considerable distances apart, in order to take advantage of the water power, and not to have to carry the charcoal and ore to them from excessive distances.

The establishment of the 'Russia' Ironworks of the VYKSOUNSKY COMPANY consisted of 400,000 acres, with various works scattered within this area, and iron manufacture in all its branches is carried on. At one or other of their works they smelt the ore, roll it into bars, tyres, hoops, plates, and sheets, draw telegraph and other wire, make nails, and construct steam-engines and other machinery. In consequence of the works lying so widely apart, the cartage is immense, and although done at a cheap rate, is a very heavy item in the company's expenses; and most of it, on account of want of roads, has to be done by sledges over the snow in winter, so that in about four months the entire stocks for the remainder of the year have to be laid in. About 1,000 horses, and something like 10,000 men, women, and boys, are engaged during the winter.—*Worcester Chronicle*, quoted by Mr. DAVID FORBES in *The Journal of Iron and Steel Institute.*

The returns from Russia are considerably in arrear, but according to an article by M. LAVRSKY, *Industrie Métallurgique et Minière de la Russe en* 1873, we find the following to give a fair statement of the production of iron and steel in Russian pouds (of 36·11 lb. English):—

	1871	1872	1873
Forge pig-iron	21,932,982	24,874,956	23,464,307
Foundry pig-iron	1,033,099	2,030,300	2,451,060
Wrought pig-iron	15,368,470	16,368,476	15,585,367
Steel	442,247	311,727	546,035

The same authority tells us that in 1873 the furnaces in activity were as follows:—

Blast furnaces	245
Puddling furnaces	522
Re-heating furnaces	700
Puddling and re-heating furnaces	20
Refinery furnaces	840
Steel furnaces	472
Cupolas	191
Air melting furnaces	88

There were 203 iron and steel works and 155 foundries in operation during the year, and these produced—

Steel cannon and artillery requisites	15,685 pouds
Iron cannon	19,325 ,,
Iron and projectiles	641,342 ,,

The foundries are reported to have made—

Castings from cupolas	1,517,257 pouds
,, from air furnaces	471,867 ,,
,, not indicated	461,936 ,,
Total	2,451,060 ,,

Mr. DORIA, in his report 'On the Trade and Commerce at the Fair of Nijni-Novgorod' (in the 'Reports by Her Majesty's Secretaries of Embassy and Legation'), gives some very exact information connected with the iron manufactures of the Ural and Viatka. The following weights of iron in different forms were imported from the foundries of the Ural and Viatka and sold:—

Years	Pouds of 36 lb.	Value		
		Silver Roubles of 2s. 4d.	£	s.
1872	4,622,000	16,421,000	1,945,367	10
1873	5,721,560	16,377,000	2,251,837	10
1874	5,567,800	15,965,000	2,103,812	10

Mr. FURUHJELM, the Russian Government Inspector-in-Chief of the Mining and Metallurgical Works of Finland, in his official report for 1874, published at Helsingfors in June 1875, gives the following information:—

Years	Blast Furnaces	Cast Iron	Wrought Iron	Manufactures
		Finland cwt.	Finland cwt.	Finland cwt.
1874	21	583,155	384,744	31,781
1873	22	573,308	347,702	23,166
Increase in 1874 .		9,847	30,992	8,615

The quantities of iron ore smelted in 1874 being—

	Finland cwt.
Lake ores, equal to 69 per cent. of the whole . .	1,102,127
Bog, equal to 4 per cent.	67,113
From Finland mines	16,740
From Swedish mines	409,275
Total	1,595,255

The following information respecting the greatly increasing iron industry of Russia has been obtained from the *Economiste Française*:—

'In 1874 the metallurgical establishments belonging to the State in the Ural Mountains, in the district of Olonetz, in the east and west of Poland, and in Southern Russia, produced 202,601 tons of cast iron, 8,994 tons of unwrought iron, 1,151 tons of steel, 8,203 tons of war projectiles, 146 tons of steel for cannon, 241 tons of iron for cannon, 169 tons of armour plate, 40,095 sabres and bayonets, 5,735 muskets and locomotives, weighing 177 tons. In the single district of Goroblagodatt, in the Ural Mountains, from 35,000 to 40,000 tons of iron ore are extracted every year, and since 1818 these mines have yielded 1,200,322 tons. The extraction is very easy, for many of the beds of ore are close to the surface and the quality is very good. The manufacture of steel is also making rapid progress, and several of the State establishments employ the Bessemer system, among others the cannon foundry at Oboucheff, near St. Petersburg. The great central market for iron in Russia is Nijni-Novgorod, to which the Ural mines alone send 100,000 tons every summer. The iron is sent down the rivers Bielaya, Kama, Volga, and Tchoussora in barges, and as the navigation is very dangerous, many of them are lost, especially on the Tchoussora. The iron sent to Nijni-Novgorod has to pass through three hands before it reaches the consumer, so that the price of it is very much enhanced. A great deal of the iron sold there is sent into the neighbouring districts and to St. Petersburg, while at Riga and Odessa it has against it the competition of foreign iron and of that sent from the State establishments of Tambof, Riazan, Vladimir, and Kalouga, which supply nearly all the south-eastern region. Further south, the unwrought iron comes almost entirely from Laishef, in the province of Kasan.

Sweden.—There were, in 1875, 321 charcoal iron furnaces built:

104 were idle,
217 in blast.

Production of cast iron being 7,712,778 Swedish tons, or 321,364 English tons. The details of production of steel in 1874 were as follows:—

Provinces	Works	Bessemer	Martin	Others	Total
		Cwt.	Cwt.	Cwt.	Cwt.
Vesternorrland . . .	1	—	—	191	191
Gefleborg . . .	3	219,350	—	—	219,350
Upsala . . .	2	—	—	3,693	3,693
Stockholm . . .	1	5,437	—	—	5,437
Kopparberg . . .	8	160,933	—	3,811	164,745
Vestmanland . . .	3	52,037	—	15,704	67,741
Orebro . . .	5	19,416	—	2,064	21,481
Vermland . . .	8	43,073	3,903	4,177	51,053
Elfsborg . . .	2	—	—	6,262	6,262
Total . .	33	501,146	2,903	35,842	539,893

See *State of the Iron Manufacture in Sweden at the beginning of* 1876, by Richard

Akerman; *Iron Mines and Mining in the Norberg Mining District*, by G. A. Granström, in the first part of the *Jern Kontorets Annaler* for 1876.

United States. *Production of Pig Iron in net tons, from* 1854 *to* 1875. *Compiled from Statistics procured by the American Iron and Steel Association:—*

Years	Anthracite	Charcoal	Bituminous Coal and Coke	Total
	Tons	Tons	Tons	Tons
1854	339,435	342,298	54,485	736,218
1855	381,866	339,922	62,390	784,178
1856	443,113	370,470	69,554	883,137
1857	390,385	330,321	77,451	798,157
1858	361,430	285,313	58,351	705,094
1859	471,745	284,041	84,841	840,627
1860	519,211	278,331	122,228	919,770
1861	409,229	195,278	127,037	731,544
1862	470,315	186,660	130,687	787,662
1863	577,638	212,005	157,961	947,604
1864	684,018	241,853	210,125	1,135,996
1865	479,558	262,342	189,682	931,582
1866	749,367	332,580	268,396	1,350,343
1867	798,638	344,341	318,647	1,461,626
1868	893,000	370,000	340,000	1,603,000
1869	971,150	392,150	553,341	1,916,641
1870	930,000	365,000	570,000	1,865,000
1871	956,608	385,000	570,000	1,911,608
1872	1,369,812	500,000	984,159	2,854,558
1873	1,312,754	577,620	977,904	2,868,278
1874	1,202,144	576,557	910,712	2,689,413
1875	908,046	410,990	947,545	2,266,581
1876	794,578	308,649	990,009	2,093,236

Since 1855 anthracite has been the leading branch of the American pig-iron industry, and since 1869 charcoal has been the least productive. In 1875 for the first time the coal and coke pig-iron production was greater than that of anthracite.

The probable Consumption of Pig Iron in the United States *in* 1872, '73, '74, '75, *and* '76:—

Commercial Movement	1871	1872	1873
	Net Tons	Net Tons	Net Tons
Production	1,911,608	2,854,558	2,868,278
Importation	245,535	295,967	154,708
Total supply	2,157,143	3,150,525	3,022,986
Exportation	2,330	1,477	10,103
Total consumption	2,154,813	3,149,048	3,012,883
Commercial Movement	**1874**	**1875**	**1876**
	Net Tons	Net Tons	Net Tons
Production	2,689,413	2,266,581	1,042,101
Importation	61,165	66,457	28,569
Total supply	2,750,578	2,333,038	1,070,670
Exportation	16,039	8,738	3,559
Total consumption	2,734,539	2,324,300	1,067,111

AMERICAN IRON TRADE.

Production of Pig Iron of all Kinds, distinguishing the Districts and Kinds of Iron.—

States	1872	1873	1874	1875
ANTHRACITE IRON.				
	Net Tons	Net Tons	Net Tons	Net Tons
Massachusetts	4,250	5,432	10,214	11,140
New York	271,343	267,489	298,428	254,935
New Jersey	103,855	102,341	90,150	64,0[illegible]
Pennsylvania	968,453	913,085	775,008	554,992
Maryland	21,908	20,407	22,344	15,540
Virginia	—	4,000	6,000	7,070
Total	1,369,812	1,312,754	1,202,144	908,046
BITUMINOUS COAL AND COKE IRON.				
Pennsylvania	365,011	430,634	497,147	371,401
Maryland	12,070	5,264	7,209	1,751
Virginia	—	—	—	7,519
North Carolina	—	—	—	—
Georgia	—	—	5,516	12,685
Alabama	—	—	—	—
West Virginia	19,846	21,106	26,731	24,177
Kentucky	27,697	27,670	24,583	26,000
Tennessee	8,360	8,602	11,543	10,300
Ohio	304,121	305,831	332,166	353,922
Indiana	39,221	32,486	11,632	20,381
Illinois	78,627	55,796	37,946	49,762
Michigan	13,382	9,531	7,693	13,000
Wisconsin	37,246	35,268	21,819	36,656
Missouri	55,569	46,016	26,724	19,931
Total	984,159	977,904	910,712	947,545
CHARCOAL IRON.				
Maine	—	780	1,661	2,046
Vermont	2,000	3,100	3,450	2,100
Massachusetts	12,820	15,704	17,777	10,115
Connecticut	22,700	26,077	14,518	10,880
New York	19,812	29,329	28,293	11,4[illegible]
Pennsylvania	45,033	45,854	40,976	34,491
Maryland	29,044	30,315	25,003	21,160
Virginia	21,445	22,475	23,451	15,3[illegible]
North Carolina	1,073	1,432	1,310	800
Georgia	2,945	7,501	4,270	3,8[illegible]
Alabama	12,512	22,283	[illegible]	25,1[illegible]
Texas	619	280	1,012	—
West Virginia	950	1,950	3,400	1,1[illegible]
Kentucky	39,699	42,219	36,644	22,270
Tennessee	34,094	34,532	37,227	18,011
Ohio	95,622	100,498	92,835	61,971
Indiana	—	—	2,100	1,700
Michigan	86,840	113,975	128,969	161,805
Wisconsin	27,790	38,880	28,973	25,483
Missouri	45,589	39,536	49,093	29,768
Oregon	—	—	2,500	1,000
Utah	—	—	200	150
Minnesota	—	—	—	—
Total	500,587	577,620	576,557	410,990

States	1872	1873	1874	1875
Recapitulation.				
	Net Tons	Net Tons	Net Tons	Net Tons
Kinds of Pig Iron:				
Anthracite	1,369,812	1,312,754	1,202,144	908,046
Charcoal	500,587	577,620	576,557	410,990
Bituminous coal and coke	984,159	977,904	910,712	947,545
Total	2,854,558	2,868,278	2,689,413	2,266,581
Production in Certain Districts.				
Pennsylvania:				
Lehigh Valley	449,663	390,969	310,730	280,380
Schuylkill Valley	232,225	230,409	232,420	125,164
Upper Susquehanna	127,260	120,304	86,245	71,731
Lower Susquehanna	159,305	157,403	137,556	79,717
Shenango Valley	160,188	160,831	150,419	137,025
Pittsburgh and Allegheny Co.	110,509	158,730	143,660	131,556
Miscellaneous coke	117,224	111,014	97,069	102,520
Ohio:				
Hanging Rock coke	23,169	28,601	26,016	16,590
Mahoning Valley	152,756	136,972	121,400	116,993
Miscellaneous coke	128,196	139,958	184,748	201,030
Hanging Rock charcoal	87,440	92,305	85,873	57,413
Miscellaneous charcoal	8,182	8,133	6,902	4,558

Production of all Rolled Iron in the United States.

States	Bar, Angle, Bolt, Rod, and Hoop Iron [1]			Total Rolled Iron		
	1873	1874	1875	1873	1874	1875
	Net Tons	Net Tons	Net Tons	Net Tons	Net Tons	Net Tons
Maine	4,710	3,994	3,700	21,210	18,644	8,100
New Hampshire	300	300	1,000	300	300	1,000
Vermont	—	—	—	6,058	10,400	6,204
Massachusetts	44,490	40,324	40,336	118,669	100,500	99,712
Rhode Island	6,000	7,170	6,648	11,062	10,616	9,584
Connecticut	11,400	11,921	9,618	11,400	11,921	9,618
New York	85,908	76,590	90,583	164,782	133,518	131,606
New Jersey	35,954	24,645	24,584	77,085	58,031	55,249
Pennsylvania	333,556	343,635	300,784	835,554	798,160	738,530
Delaware	8,274	6,960	9,316	11,617	11,818	16,252
Maryland	1,960	8,455	6,279	68,025	68,601	46,667
Virginia	7,462	11,086	12,744	12,808	16,688	15,843
Georgia	1,840	1,406	3,360	10,624	9,467	10,326
Alabama	500	1,000	1,000	600	1,000	1,000
West Virginia	2,863	1,600	1,805	51,726	56,532	64,299
Kentucky	25,675	18,236	13,936	37,955	34,518	33,961
Tennessee	2,688	1,573	1,005	16,861	16,920	13,745
Ohio	103,898	94,413	93,890	272,066	220,370	257,591
Indiana	4,500	7,376	11,465	26,006	35,507	44,073
Illinois	5,240	2,500	6,000	143,017	134,093	200,676
Michigan	2,284	4,207	—	8,542	8,208	3,450
Wisconsin	—	275	14,437	39,495	29,955	42,840
Missouri	7,608	10,870	10,144	22,621	36,387	31,540
Wyoming Territory	—	—	—	—	—	7,000
Kansas	—	—	—	—	2,000	5,000
California	6,045	9,205	6,121	7,420	16,221	14,194
Total	703,964	687,650	663,755	1,966,445	1,839,560	1,890,379

[1] Plate and sheet iron, cut nails and spikes, omitted.

The production of rails of all kinds in the United States since 1870:—

	Net Tons
1870	620,000
1871	775,733
1872	1,000,000
1873	890,077
1874	729,313
1875	792,512
1876	879,629

The production of Bessemer steel in 1876:—

In Pennsylvania, 5 Bessemer steel establishments in operation.
In Illinois, 3 " " "
In New York, 1 " " "
In Ohio, 1 " " "
In Missouri, 1 " " "

	1874 Net Tons	1875 Net Tons	1876 Net Tons
Pig-iron and spiegeleisen converted in	204,352	395,956	639,474
Spiegeleisen alone used	—	33,245	46,980
Bessemer steel ingots produced	191,933	375,517	525,996
" rails "	144,944	290,863	412,461

The Total Production of Steel of Various Kinds other than Bessemer in 1876.—

Districts and States	Crucible Steel	Puddled, Open Hearth,* and Blister Steel	Total
	Net Tons	Net Tons	Net Tons
New England	1,093	6,085	7,183
New York	2,300	139	2,939
New Jersey	6,806	652	7,458
Pennsylvania	28,217	15,148	43,365
Ohio	700	9,558	10,258
Maryland and Tennessee	261	214	475
Total	39,382	31,796	71,178

Tennessee, U.S.—From the most trustworthy information, the iron production of Tennessee (charcoal and bituminous coal) since 1871 is as follows:—

	Charcoal	Bituminous Coal and Coke	Total
1872	34,094 tons	8,360 tons	42,454 tons
1873	34,532 "	8,602 "	43,134 "
1874	37,227 "	11,543 "	48,770 "
1875	18,011 "	10,300 "	28,311 "

Rolled iron, excluding rails:—

1873	2,686 net tons
1874	1,573 "
1875	1,005 "

Cut nails and spikes:—

1874	13,210 kegs
1875	9,795 "

About 800 tons of hammered iron are made annually in eighteen Catalan forges. Railroad iron is made only at Chattanooga in one establishment, which turned out 12,260 tons in 1875.

There are four distinct iron belts or areas in the State of Tennessee, occupying in whole or in part forty-four counties, excluding the Cumberland Tableland.

(1.) *The Eastern Iron Belt* extends through the State and lies mainly in front and

* Siemens-Martin steel.

at the base of the Unaka Mountains. This belt embraces the extreme eastern tier of counties, viz.:—Johnson, Carter, Washington, Green, Cocke, Sevier, Blount, Monroe, McMinn, and Polk; to these we may add Sullivan, which adjoins this belt on the north-west.

(2.) *The Dyestone Belt* skirts the eastern base of the Cumberland Tableland, or rather of Walden's Ridge, from Virginia to Georgia; spreads out laterally from 10 to 20 miles into the valley of East Tennessee; the Sequatchee and Elk valleys are included.

(3.) *The Cumberland Tableland* is co-extensive with the coal-measures of the State, and extends into Kentucky and Alabama.

(4.) *The Western Iron Belt* lies west of Nashville, or, say, west of the Central Basin.—An Address delivered before the *American Philosophical Society*, New York, by ABRAM HEWITT.

The Directory of the Ironworks of the UNITED STATES gives the following summary, showing the state of the iron and steel industries on January 1, 1876:—

Total number of blast furnaces in the United States	713
,, annual capacity of above in net tons of pig iron	5,439,230
,, number of rolling mills	332
,, ,, puddling furnaces	4,475
,, annual capacity of rolling mills in net tons, finished iron	4,159,760
,, ,, ,, rail mills in net tons, heavy rails	1,940,300
,, number of Catalan forges making blooms direct from ore	39
,, annual capacity in blooms and billets in net tons	59,549
,, number of bloomeries making blooms from pig iron	59
,, annual capacity in net tons of blooms	60,200
,, number of BESSEMER steel works	11
,, annual capacity in net tons of steel ingots	500,000
,, number of BESSEMER converters	24
,, ,, open-hearth steel works	16
,, ,, ,, furnaces	22
,, annual capacity in net tons of steel	15,000
,, number of crucible and other steel works	39
,, annual capacity in net tons of merchantable steel	108,250
,, quantity of crucible steel in the above in net tons	15,000

PIG IRON IN THE WORLD.—The following estimate has been made in the main by a correspondent of the *Colliery Guardian* for December 15, 1876; it has, however, been thought necessary to alter a few of the figures:—

Cast or Pig Iron by Countries	Years	Gross Tons	Per Cent. of Total
Great Britain	1872	6,365,462	44·95
United States	1875	2,023,733	15·18
Germany	1874	1,750,000	13·13
France	1875	1,415,728	10·62
Belgium	1874	613,656	4·60
Austria and Hungary	1874	400,000	3·00
Russia	1873	417,654	3·13
Sweden and Norway	1874	326,041	2·42
Luxemburg	1872	184,573	1·38
Italy	1872	26,000	·20
Spain	1870	53,112	·40
South America and Mexico	—	15,000	·11
Canada	—	10,000	·08
Japan	1871	9,370	·07
Switzerland	1872	7,600	·06
Turkey in Europe	—	25,000	·19
All other Countries	—	60,000	·45
Total	—	13,328,755	100·00

The production of Great Britain in 1876 was 6,555,997 tons, value 16,062,192*l.*

J

JAPAN BLACK. See Brunswick Black.

JARGOON. See Zircon.

JET. (Vol. iii. p. 8.) Of late the chain of hills from Ingleby Greenhow towards Northallerton have been the chief places worked for jet, and at present the inner sides of the hills converging into Billsdale furnish the bulk of the jet now sent from Cleveland to the chief seat of manufacture—Whitby. Along the coasting cliffs jet is sought by what is called 'dressing,' or literally quarrying down the seaward face of the cliff, and some valuable coastside seams have been discovered by the action of the sea, but in the hills tunnelling, much in the manner of the Cleveland iron mines, but in a less systematic mode, is carried on. Generally a drift is run in for about 80 yards nearly level; the shale and earth being run out and tipped down the face of the hill. From the drift cross sections are cut about 150 ft. in length, and in these the miners pull down with pick and shovel the earth, retreating before it till each way is thus worked out. The mode of working the mines is peculiar: it is neither by royalty on output nor on lease of pits, but it is by payment for the right to work from a certain area of foreground—usually 200 yards—to any depth, the number of men being restricted to six on an average for the length of foreground stated. Three years ago in Billsdale alone there were above 200 jet miners thus at work, with a few companies near Guisborough additional. Now, through the decline in the demand and the importation of Spanish jet, the number is less. The mode of payment of the miners varies; in one or two instances the amount realised by the sale of jet, after the payment of ground rent, is equally divided amongst the five workers and the 'jet master' who has furnished the capital; in another the co-operative system has been tried, the man receiving a certain amount of subsistence money, and equal shares in half of the net receipts, the remaining half being the master's remuneration; but the bulk of the miners receive a weekly wage, and they prefer this system. Hence the risk is generally the jet master's, and though the price of jet has been high—in some cases as much as 16*s*. per lb. has been paid for choice specimens—yet when it is remembered that the price is a fluctuating one, that the quantities found are usually small, and that they are lessened by the 'doggers' found in the seam and by the dazed jet—that which will bear no polish—it is a hazardous speculation. Whitby is the seat of jet 'manufacture.' The first process is—after the removal of the 'scar,' dirt, &c.—the sawing of the block into sizes suited to the objects for which it is to be used, and then the rubbing of it on small grindstones, driven rapidly by a treadle. It then passes into the carving rooms. Here, with small leather-bound chisels, the pattern is cut, foot lathes cutting the holes in flower pieces, &c., and of late the artistic nature of these cuttings and carvings has been greatly improved. After this cutting the carved goods are polished, which is effected by their being held against rapidly revolving wheels, which are covered with chamois leather, the hollow parts being rubbed with strips of list, the polish being given by lampblack. The value of the jet trade to Whitby has been as low as 20,000*l*. per annum, but probably now (1876) the produce of this manufacture will be near 100,000*l*., whilst the number of persons employed in Whitby in the trade is said to be above 1,200.

JUMBA BEAN. See Mimosa Seed.

JUNCO. (*Juncus*, 'the rush.') The stems of several species are collected and prepared in different countries, the pith to form candle wicks (hence the rush-light), and the preparation of fibres and the manufacture of mats. See Textile Materials.

JUTE. (Vol. iii. p. 11.) Considerable difficulty has attended the cleansing of the heavy root ends of jute. A machine for effecting this desired end has lately been patented by Messrs. M'Keane and M'Grath in this country and in India. The idea has more than once presented itself to several people why the process of 'snipping' could not be used in India for removing the whole of the root or butt, for the gain would be great inasmuch as instead of a 'cutting,' only useful for paper-making, the root would be converted into tow—*i.e.*, cleaned and split fibre, like so much wool—and the pointed end would be left on the long stick. Some of the present make of machines have actually been sent out to India for this purpose, but were found quite useless owing to the small quantity each would do per day, which would not suit the requirements of this enormous trade, especially as the great bulk of it is done in six months of the year. This new invention claims not only to have entirely overcome this difficulty, but to facilitate the work by reducing the manual labour to a minimum. It is said to take the strick in the size in which it is baled, and by one operation thoroughly to 'snip' or comb off the root end, twist the strick, and double it in two ready for the

press, and, although remarkably easy to drive, will pass eight or ten times the quantity an ordinary snipping machine can per day. To sum up, the advantages claimed by the inventor, Mr. M'Keane, for this machine are—1. Increased production, or quantity of jute snipped per day; 2. Greater regularity of work both in quality and quantity; 3. Increased value to the spinners of jute snipped, over jute cut; 4. Increased value of tow over cuttings; 5. More jute will be snipped, than it will pay to cut,—owing to the low value of cuttings; 6. No baling of cuttings or tow, as all the latter should be consumed by local mills; 7. More jute can be put in the bales, and be no more tightly pressed, owing to the bulky coarse ends being removed; 8. By the process of snipping the tow can be separated according to quality, which varies with the jute from which it is taken, and sold at its relative value.

In 1875 we imported from British India and Burmah 3,404,983 cwt. of jute, valued at 2,570,192*l*., and from other countries 11,634 cwt., valued at 5,320*l*., giving our total importation as 3,416,617 cwt., and total value 2,575,512*l*.; and of jute yarn and waste we imported 1,620 078 cwt., valued at 54,651*l*., principally from France.

K

KAINIT, CRUDE AND CALCINED. The name given in the trade to the potash salts. Kainit is used largely in the manufacture of artificial manures.

KAINITE, properly Cænite, from *καινός*, *recent*. A potash salt found at the Stassfurt Salt Mine, along with kieserite and carnalite. Dance regards it as nothing more than impure picromerite, the analysis given by Reichardt being—

Sulphuric acid	39·8
Magnesia	9·9
Potash	23·5
Water	26·8

This analysis was made on Reichardt's schönite, a salt obtained by separating the chloride of magnesium from kainite by means of alcohol.

The name Kainite was given by Lincken to the salt found at Stassfurt. It has been analysed by Graf (*Berg- und Hüttenmännische Zeitung*, xxiv. p. 288), by E. and H. Reichardt (*Jahrbuch für Mineralogie*, 1866, p. 337), and by Philip (*Zeitschrift der deutschen geol. Gesellschaft*, xvii. p. 649).

The Diamond Boring Company are reported (December 1876) to have discovered an immense deposit of this kainite in Germany, which it is expected will be exceedingly valuable, on account of the potash salt.

One part of water at 17° dissolves 0·467 part of anhydrous crude kainite; the density of the saturated solution is 1·256.—Von Hauer, *Jahrb. geol. Reichsanstalt*, xx.

According to A. Jacot, the beds of Kaluss yield more than 81,100 kilos of the chloride of potassium daily.—*Comptes Rendus*, lxxiii.—*A Dictionary of Chemistry*, 2nd Supplement, Watts.

KAOLIN. *China or porcelain clay as a clarifying agent.* The *Centralblatt für Agrikultur-Chemie* for January 1875 contains a note by R. Hoff, denying the statement of Mack, that kaolin used to clarify wine attacks its red colour more than a corresponding proportion of gelatin or isinglass. He says below 10° C. the action of kaolin is imperfect.

Much has been said respecting the superior character of the porcelain clays of China. The following analysis of a kaolin from Sikang, in China, will be interesting:—

Loss by ignition	11·2
Silicic acid	50·5
Alumina	33·7
Ferric oxide	1·5
Magnesia	0·8
Potash	1·9

By A. Heintz. Dingler's *Polyt. Journal*, ccxxi.

Cornwall in 1876 produced 105,275 tons, and Devonshire 25,000 tons.

KERMESITE. The red oxysulphide of antimony. See Antimony.

KEROSENE. New South Wales. *Kerosene Shale.*—This mineral is found abundantly in the coal measures of New South Wales, usually in the form of more or less lenticular deposits.

In colour the mineral varies from brown—sometimes a greenish brown—to jet

black. It usually weathers white; and as the surfaces of the joints are also coated with a thin film of a white clay-like substance, the mineral is sometimes termed 'white coal.' The fracture is large conchoidal. When struck it gives out a woody sound. Can be cut by the knife into comparatively thin shavings. Gives a black shining streak and a brown powder. Thin sections, under the microscope, show an amber, brown, and black reticulated structure. The brown portions are those which transmit the light, and the black are the opaque portions. Mr. E. T. NEWTON, assistant naturalist to the Geological Survey of England, has recently written a valuable and interesting paper upon the microscopic structure of the so-called white coal and tasmanite of Tasmania. See *Geol. Mag.*, September 1875.

Different samples vary very much in composition. From analyses made by Professor A. LIVERSIDGE the following results were obtained:—

Greta.

Moisture	·48
Volatile hydrocarbons	61·66
Fixed carbon	25·13
Ash (grey)	13·21
	100·00

Murrurundi.

	1	2
Moisture	1·00	1·01
Volatile hydrocarbons	66·33	71·70
Fixed carbon	6·27	6·17
Ash (grey)	26·40	21·12
	100·00	100·00

	Hartley.	*Wollongong.*[1]
Moisture } Volatile hydrocarbons }	82·24	82·50
Fixed carbon	4·97	6·50
Ash	12·79	11·00
	100·00	100·00

Specific gravity = 1·052.

Some of the Hartley shale has been known to yield as much as 180 gallons of crude oil per ton.

Some specimens from Hartley give on fracture very long flexible concavo-convex flakes. Again, some shales like those from Murrurundi are full of little specks of a white aluminous pipeclay-like mineral.

A very similar shale is found in New Caledonia; the physical properties are similar, and the chemical composition is shown by the following analysis:—

Moisture } Volatile hydrocarbons }	65·17
Fixed carbon	8·71
Ash	26·12
	100·00

Specific gravity = 1·238.

The kerosene shale, when heated in a tube, neither decrepitates nor fuses, but there distils over from it a mixture of gaseous and liquid hydrocarbons.

It is found at Stony Creek, Barrima, Wollongong, American Creek near Murrurundi, Greta, Lake Macquarie, and Hartley.

KIESERITE (*Hydrosulphate of Magnesium*). A mineral found in the rock salt of Hollstatt by A. SIMONY. It forms about 12 per cent. of the refuse salt (*Abraumsalz*) of Stassfurt. It is used for washing wool, and for the preparation of 'permanent white' by precipitation with the chloride of barium. Glauber salts are also manufactured from it.—H. GRÜNEBERG, *Deut. Chem. Ges. Ber.*

KILLAS. (Vol. iii. p. 17.) A considerable number of the clay-slate rocks of Cornwall have been analysed by Mr. J. A. PHILLIPS. Typical killas is a grey-bluish

[1] By Prof. SILLIMAN.

grey, or greenish-grey slate, and when weathered is brownish-yellow or buff. Its typical composition is—

$$H^2O\ 4{\cdot}08 - SiO^2\ 60{\cdot}42\ P^2O^5\ 0{\cdot}21\ Al^2O^3\ 20{\cdot}835\ Fe^2O^3\ 1{\cdot}89\ Mn^2O^3\ 0{\cdot}41\ CaO\ 1{\cdot}71\ K^2O\ 0{\cdot}77\ Na^2O\ 1{\cdot}55.$$

Philosophical Magazine, (4) xii.

KJERULFIN, a mineral found in Bamle, in Norway. The composition corresponds with the formula $2Mg^3(PO^4) + CaF^2$, a small portion of the calcium being replaced by sodium.—F. v. KOBELL, *Jour. p. Chem.*

KNEBELITE. This mineral has long been known as occurring at the Dannemora Iron Mines. It has recently been found in large quantities in the iron mine of Hillärg, Dalarne, Sweden. Analysis shows its composition to be—

$$SiO^2\ 33{\cdot}14\ .\ FeO\ 40{\cdot}96\ MnO\ 19{\cdot}35\ CaO\ 6{\cdot}35.$$

Chem. Centr.

KUKUL OIL. See CANDLE NUTS.

L

LAMBAY PORPHYRY (*a local name*). A beautiful ornamental stone, which is found amongst the Silurian rocks, and has evidently been intruded before the Old Red Sandstone period. It has a dark green base, enclosing pale green crystals of orthoclase, often an inch in length. The dark colouring matter of the base is due to minute crystalline grains of magnetite, with a little chlorite.

LAMP, PLUMMET. The plummet lamp, for surveying in mines, is the invention of ECKLEY B. COXE, of Drifton, Luzerne County, Pa., United States, and was brought before the meeting of the American Institute of Mining Engineers at Bethlehem. This was improved upon recently by Mr. COXE, and brought before the Association at St. Louis. The following is from Mr. ECKLEY B. COXE's paper:—

'Mining engineers, who are in active practice in those districts where fire-damp is met with in the mines, know how dangerous their work is when they are called upon to survey such mines, particularly when they are obliged to run lines in those parts of the mine which have been unworked, since by opening of doors and brattice to get the sights they are liable to disarrange the currents of air, and cause any fire-damp that may have accumulated in the old workings to find its way into the levels where the party is at work. It is, therefore, very dangerous to leave an open light (such as the original form of plummet lamp) in an old breast or gangway, even when the safety lamp has shown that no fire-damp is present; for the opening of the doors, &c., may drive the fire-damp to the light, and thus endanger the lives of the engineers.

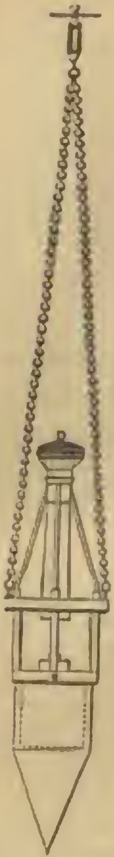
'The improved form of plummet lamp (*fig.* 2395) can be used either with or without safety apparatus. Upon the top of the plumb-bob portion of the lamp a screw is cut, upon which a ring, A, is screwed (*fig.* 2396). On the external cylindrical part of this ring two small conical holes are drilled, 180° apart. The compensating ring, by which the plumb-bob part of the lamp is suspended, passes over the ring, A, and is fastened to it by two small screws having conical points, which fit into the conical holes in the ring, A.

'The safety apparatus resembles, to a certain extent, that of the MUESELER lamp. It consists of a ring, B, and plate, C, which are united by four rods. The plate, C, has a cylindrical hole in the middle, and four apertures distributed radially around it. In the central cylindrical hole is fitted a conical brass chimney, which projects below the plate, C, and is fastened to the latter, being kept vertical by four wire braces or stays, which are soldered to the top of the chimney and to the outer edge of the plate, C.

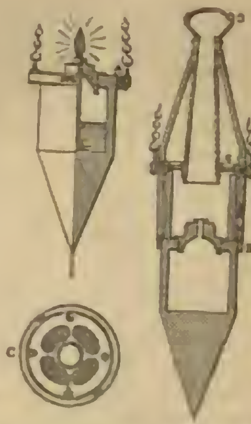
'The top of the chimney terminates in an inverted frustrum of a cone, which is made hollow, and is drilled full of small holes. The inside is lined with one thickness of wire gauze. On the upper part of the cone is screwed a brass cap, D, composed mainly of a brass ring and wire gauze; the smoke and the products of combustion pass out through the latter. This cap must be cleaned from time to time (three to ten hours), depending upon how much the lamp is used, and how much it smokes. It is well to carry an extra cap in the pocket, which can be put on when the dirty one is taken off. An easy way to clean the cap is to allow a jet of steam to blow through it. The four radial apertures in the plate, C, are also covered by two thicknesses of wire gauze. Between the top of the plumb-bob and the bottom of the

plate, c, and inside of the four vertical wires, is inserted a cylinder of glass. When the safety apparatus is to be used, the compensating ring is removed from the ring,

2395



2396



A, and placed upon the plate, c, which has two conical holes corresponding to those in the ring, A; the ring, A, is unscrewed from the top of the plumb-bob, and the ring, B, is screwed on in its place, with the glass cylinder on top of the plumb-bob. As the ring, B, is screwed up, the glass cylinder is clamped between the plumb-bob and the plate, c, making nearly an air-tight joint; the lamp, having been lighted before the safety apparatus was screwed on, is now ready for use. The air passes down through the four radial orifices in the plate, c, which are covered with two thicknesses of wire gauze, is heated by the flame, and rises through the chimney, passing out through the wire-gauze top.

'The glass is thick and well annealed. I have allowed the lamp to burn nearly an hour, until the glass was quite hot, and then thrown cold water upon it, without producing any effect whatever on the glass. The wick should not be high, as a very short one gives light enough, and not much smoke. The best kerosene (of as high a test as possible) should be used in the lamp, since the latter gets warm. The top of the wire-gauze covering of the chimney becomes more or less clogged with lampblack, which can be removed from time to time with a fine brush.'

LAMP, SAFETY, for mines. See SAFETY LAMP.

LANDOLPHIA FLORIDA. The name of a creeping plant growing on the West Coast of Africa, from which a large quantity of india-rubber is collected. See INDIA-RUBBER.

LAVA. (Vol. iii. p. 46.) 'A Report on the Chemical, Mineralogical, and Microscopical Lavas of Vesuvius, from 1631 to 1868,' by the Rev. SAMUEL HAUGHTON and Professor EDWARD HULL, appears in vol. xxvi. of the *Transactions of the Royal Irish Academy*, from which the following analyses have been abstracted. It should be stated that the chemical and mineralogical part is by Dr. HAUGHTON, aided in the analyses by Mr. WM. EARLY, while the microscopical portion is by Mr. E. HULL. The minerals found by the latter to be present in all lavas are leucite, anorthite, augite, magnetite, and nephelite, and in many of them traces of sodalite, olivine, hornblende, and mica; in several sanidine, and in a few apatite.

In the discussion of the chemical results with reference to the proportions of their mineral constituents, Dr. HAUGHTON, by a simple mathematical method, obtains the maximum and minimum of the amount possible for each constituent. The probable proportions of some of the constituents are then deduced from their relations in composition, and a mean possible value obtained for the rest.

The amount of 'paste' is arrived at through the assumption that 'of the numerous possible solutions, that will be the occurring one in nature which involves the largest amount of definite minerals, and the least amount of indefinite paste.'

	Gravina	Granatello	Della Scala	C. de S. Vito	C. de Salvatore	The Atrio	T. de Greco
	1631	1631	1631	1767	1834	1823	1861
Leucite .	38·2	33·6	40·6	41·4	39·7	36·8	34·2
Anorthite .	6·6	0·6	6·9	9·4	0·4	11·8	11·6
Magnetite .	7·14	4·45	4·0	6·0	9·7	3·35	3·71
Olivine .	trace	trace	trace	trace	trace	trace	—
Augite . .	28·6	41·2	31·1	25·1	27·4	28·7	30·4
Hornblende	trace	trace	—	—	trace	trace	—
Mica . .	trace	trace	—	—	—	—	—
Nephelite .	10·5	10·0	6·5	8·6	11·2	11·5	10·9
Sodalite .	trace	trace	trace	—	—	trace	trace
Apatite .	—	0·44	1·1	—	—	trace	—
Paste . .	8·96	8·71	8·9	8·6	11·2	9·6	9·16

LAVAL-CATECHU. A new dye drug, introduced to the trade by a German house (Fourrier). See Dyes.

LAZULITE. (Vol. iii. p. 46.) This mineral has been found in considerable quantities in Canada.

LEAD AND LEAD ORE. Canada. Galena occurs in nearly all the locations around Lake Superior. Especially it is found at Silver Lake, at a distance of about 6 miles northward from the head of Thunder Bay, and at an elevation of 500 feet above Lake Superior. The remarkable vein which occurs at this place has been thus described by the *Geological Survey of Canada*:—

'A short distance to the west of it there is an enormous brecciated vein, some 250 feet in width, composed of masses of the country rocks, cemented together with quartz, and some barytes and calcspar, and holding small quantities of galena, copper and iron pyrites, and blende. This has been traced for about three miles. In approaching Silver Lake it contracts rather abruptly, but sends out several branches to the eastward, of which four or five have been followed for considerable distances, and are found to be much richer in galena and blende than the great vein. The latter is on the line of a dislocation, which increases in going west, and appears to die out to the eastward. The downthrow is on the north side, and brings the indurated calcareous marls of the Nipigon series on that side down to the level of the iron-ore beds (at the base of the series) on the south side, amounting to 400 feet or upwards on this location. The gangue consists of calcspar, with some quartz and barytes, and holds a good proportion of galena and blende. This ore is found in Black Bay, St. Clair Location, Pointe-aux-Mines, Limerick, and Loughborough, Ontario.

'The country rock at the Frontenac Lead Mine consists of greyish and reddish gneiss, interstratified with thick bands of crystalline limestone, all striking NNE. and SSW., and dipping to the westward at a high angle. The vein cuts these at right angles, and at the surface has a slight underlie to the north, although at a depth of 60 feet in the main shaft it becomes vertical. The veinstone consists of calcspar, generally showing a banded structure, and, in addition to galena, containing small quantities of blende, and iron and copper pyrites. The galena occurs in scattered bunches throughout the whole vein, but appears to be most abundant towards the north wall.'

Japan. Lead glance is found in many parts of Japan, but it is nowhere worked to any great extent; the native method of working is so very incomplete, and the lead mines have not yet been ventured upon by foreigners. There is a fine vein, 4 feet wide, containing good lead ore, in the Hosokura Mine, near Kawaguchi; but, as the water has got in, it is nearly abandoned—the natives have not sufficient machinery for pumping water out of mine. There is another lead mine at Hakŏsan; the vein is rich in good ore, but not more than 3 tons are produced annually, for the air is very bad, and no means of ventilating have yet been adopted. There is only one other lead mine of any account in Japan, and that is situated in Omi: this also is worked according to the native idea—levels are driven into the side of the hill, and the water is got rid of by means of an adit; the levels driven entirely without method or forethought; the harder parts are broken down with gunpowder. The vein dips at a

high angle; it is wide, but the lead only occurs in thin straggling veins, or in pockets. The ore is galena, intermixed largely with iron ore, magnetic and arsenical pyrites, containing also mispickel, and occasionally copper pyrites. The lead is very poor, yielding in the furnace only from 4 to 5 per cent. of metal, and this yields 8 per cent. of silver. A richer vein has also recently been struck; this, I hear, yields 60 per cent. of lead and 125 ozs. 8 dwts. of silver per ton of ore.

It is rather to be wondered at that the lead of Japan is not more worked, for it is of fairly good quality, and in some quantity; but in the year 1874 only 165 tons (worth 4,343*l.* 12*s.* 11*d.*) were produced, while in 1873 the Japanese imported no less than $84,633 worth, in English money 17,644*l.* 7*s.* 0*d.*—*Consular Report*, 1876.

A few months (1876) ago Mr. Gerris read a paper before the Asiatic Society of Japan on the above subject, in which, among other things, he said that Japanese history did not mention the year when lead was obtained for the first time in Japan.

Lead is a metal not much used by the Japanese. The reason for this cannot be the want of ore, as has wrongly been stated by many authors, for we have the best proofs (continued the author) that galena is far from being rare in Japan. The ores in which lead occurs in Japan are:—

1. *Galena, or lead glance* (sulphide of lead).—We have seen several varieties; the finest kind consists of crystalline aggregates of large cubes, which readily cleave in directions parallel to their faces. It is found frequently in the same veins with copper pyrites, and contains often a small quantity of sulphide of silver. The extraction of lead out of this mineral is effected by a roasting process, nearly similar to the old western method. In many samples we found a small quantity of silver. The largest amount of silver we found in lead glance is about 1 per cent., according to the Japanese works on this subject. Galena is found in many places in Japan, but still the quantity of lead produced by the Japanese has been small up to the present time. It is not easy to understand why lead metal has been and is still a regular article of import from Europe. It is true bar iron is also an article of import, although good iron ore is abundant in Japan; but this anomaly is caused by the difficulty of smelting good bar iron out of the ores, which is not so with the extraction of lead out of galena. The latter process is much easier than the extracting copper out of copper pyrites, or iron out of iron minerals.

Lead glance occurs in the following provinces of Japan:—

Good ore, with 1 q. per mille silver—Higo (south-east part of Oshobata). Contains silver—Hiuga (Go-gun Sugiki), Satsuma (Jiu-ni-gun), Bungo (Hachi-gun, Uwagayama). Together with copper pyrites—Echigo (Jiu-ichi-gun), Bingo (Jiu-shi-gun), Suwo (Roku-gun), Kii (Shichi-gun), Rikuzen (Jiu-shi-gun), Cho-shu (Hagi), Rikuchu (Jiu-gun), Sendai (?), Yechizen (Hachi-gun), Iwami (Gin-san), Yechiyo (Shichi-gun), Yeso (near Hakodate) (a), Dewa (Akita, Kowachidane), Mino (Ni-jiu-ichi-gun), Musashi (Ni-jiu-ni-gun). Contains much silver (1 per cent.)—Hida (San-gun), Iwashiro (Ku-gun).

Although galena is the only lead mineral used in Japan for smelting lead, there are still some compound ores to be found, of which the following occur in the largest quantity:—

2. *Lead Antimony Ores*, several varieties:—Jamesonite in long radiated, fibrous crystalline masses, of a leaden-grey colour. Plagionite or Rosenite in granular aggregates or amorphous masses, of a dark black-grey colour. Heteromorphite or antimony feather ore in fibrous aggregates, of a dark grey colour.

All these minerals contain lead, antimony, and sulphur as chief elements; often some iron and other impurities. They seem to be found at very many places in Japan. We received samples from Higo, Ohobata, Higo, Hitoyashi, the island of Amakusa, Hiuga, and Satsuma. These ores have no practical value, because it is too difficult to separate the lead from the antimony by melting, and also because lead and antimony are found in better minerals, as galena and antimony glance.

The metallurgy of lead is thus conducted:—The galena is first separated by mechanical treatment from the foreign stones, afterwards coarsely powdered and heated in a globular loamy furnace, the interior sides of which are covered with a layer of fireproof clay. The bottom of this furnace inclines conically, so that the smelted metal runs to the point in the midst, and can be received there. The tubes of two bellows reach through opposite openings in the side of the furnace. Wood is used as fuel. When the galena is fused it is converted by the air of the bellows, partly into sulphate of lead, and partly into lead metal, whilst a portion of the sulphur escapes, together with the products of combustion, as sulphurous acid. Immediately afterwards this portion of metallic lead acquires oxygen, and is thus converted into oxide of lead. Another portion of the galena remains unaltered. After this roasting process the second operation commences. A fresh supply of fuel is thrown into the furnace, causing a greater heat, in order to convert both the sulphate of lead and

the sulphide of lead into metallic lead and sulphurous acid. The fluid metal is then collected into the receiver and cooled. The lead thus obtained is very impure, and contains still a large amount of oxide of lead, and some sulphide of lead. It is melted, therefore, again in a smaller furnace with some charcoal, in order to reduce the oxide of lead. The sulphide of lead rises with other impurities to the surface of the melted lead, and is scooped away carefully. The pure metal is then finally cast into small iron cans, or into sheaves and cakes.

MISSOURI. The lead-mining region proper of South-east Missouri is embraced in an area of about 25 miles in width by about 100 in length. The country embraced in this district is very broken, and traversed by ridges from 100 to 300 feet in height, with an occasional knob rising higher.

Porphyry forms almost the entire substructure of the region, with here and there outcrops of granite. The crystalline rocks were eroded into ridges and valleys before the deposition of the limestone took place. These porphyries are older than the Silurian limestones.

Modes of Occurrence of the Lead Ores.

A. As float mineral.
B. Deposits in the limestone.

Float mineral is a term applied by the miners to designate that mode of occurrence where the galena is found imbedded in the superficial soil immediately overlying the limestone. Occasionally large masses of the galena will be concentrated in a small area only a few feet from the surface, but being so irregularly distributed that the mining is very uncertain. Instances of this mode of occurrence, where the yield was very large, sometimes occur: at one point the miners took out from five to eight thousand pounds to the man, and the masses of ore weighing from a few pounds to several tons. A single piece weighed 7,800 lb.

The deposits occurring in the limestone may be subdivided as follows:—

I. Disseminated ore.
II. Deposits in flat sheets.
III. Vertical fissures.
IV. Horizontal fissures.

I. The disseminated lead ore usually occurs in a stratum of limestone varying from 2 to 6 feet, occasionally reaching a thickness of 15 or 20 feet; the beds of limestone are nearly horizontal, usually having a dip of 8° to 10°. Rarely does the inclination become greater.

The galena in this formation seldom occurs alone, but is usually associated with iron and copper pyrites; and at some points the latter mineral occurs in considerable quantities, and in a few cases, as at Mine la Motte, nickel and cobalt ores are found. It will be remembered that the Mine la Motte was especially an object of interest in the days of Laws, of the Mississippi Scheme.

II. *Deposits in 'Flat Sheets.'*—There are two ways in which the 'flat sheets' occur; one is in strata containing the disseminated ore, and is caused by greater quantities of the ore being concentrated throughout. The stratum in some places is only 19 inches thick, but the lead-bearing stratum throughout the district varies very much in thickness; this is especially the case at Mine la Motte, where it changes in a short distance from 2 or 3 feet to 8 and 10, and at some points it reaches a thickness of 20 feet; the whole stratum contains the mineral in sufficient quantities for mining. This same stratum at Mine la Motte, besides being very rich in galena, at certain points contains considerable quantities of copper pyrites, and a variable percentage of cobalt and nickel ores.

III. *Vertical Fissures.*—Vertical fissures may be farther divided into 'true veins,' 'gash veins,' and 'stock-werk.'

A 'true vein' is a vertical opening almost invariably filled with a gangue, and if a lead-ore vein, the gangue usually consists of galena, frequently in crystals, associated with quartz, calcspar, heavy spar, iron and copper pyrites, and not unfrequently fluor-spar, zinc blende, and other minerals.

There are several points in Missouri where vertical veins occur and are claimed to be 'true veins;' they have all the appearance of being such, but it is doubtful if they extend below the set of limestone beds in which they occur.

'Gash veins' are of much less importance than the true vein formation just discussed; the principal distinction between the true and gash vein is the certainty of the former's yield and the great depth to which it can be worked.

IV. *Horizontal Fissures.*—The lead ores of Missouri, when found in a horizontal position, occur in caves, pipe-veins, and stock-werk.

Caves.—This mode of occurrence is one of the most interesting to the scientific observer, and on account of the quality and quantity of the ore thus found, one of the

most important to the economist. The 'caves' are horizontal fissures in the rock, which have neither been produced by internal agencies, as the 'true veins,' nor by shrinkage, as the 'gash veins,' but have been produced by the dissolution and removal of the softer portions of the rock. The formation is composed of several series of limestone; that bed in which the lead ores occur is *softer* than either the overlying or underlying limestone, and consequently water containing carbonic acid percolating the rock would naturally attack the softer and more porous rock. The water, acting as a solvent upon the rock, would dissolve out portions, until a perfect network of horizontal fissures was formed, passing into each other at every angle, and varying in size from a few inches to many feet in width and height, according to the nature of the rock. After the formation of these caves, they were then refilled by water passing slowly through and depositing the various minerals held in solution.—'On the Occurrence of Lead Ores in Missouri,' by JAMES R. GAGE, M. E. ST. LOUIS, *Transactions of the American Institute of Mining Engineers.*

NEW SOUTH WALES.—The sulphide of lead is widely distributed over the colony.

Localities.—Near Inverell, and other places in New England; at Talwal Creek, on Yalwal Water; Reedy Creek; Wallabadah; on the Peel; the Page, Isis, and Hunter Rivers; at Burrowa, in quartz veins; with copper ores, on Lawson's Creek, a tributary of the Cudgegong; at Gulgong; Jugiong Creek; Crookwell River; Wareo, near Humewood; near Bathurst; Wellington; Sandy Swamp; at Mylora Creek, near Yass, in a quartz porphyry; at Woolgarloo, in association with fluorspar; near Bombala; at Kiandra, in quartz veins.

In all cases the galena is more or less rich in silver.

PRUSSIA. *Lead produced in 1873. The latest available return.*

Provinces	Weight Extracted	Value per Tonne
	Tonnes = 984 lb.	Francs
Silesia	12,709	273.18
Hanover	19,511	268.25
Westphalia	6,645	253.16
Hesse Nassau	9,735	222.08
Rhine Provinces	46,968	194.75
Total and Mean	96,568	227.52
Production of 1872	90,168	206.27
Increase	6,400	21.25

Zeitschrift für das Berg-, Hütten-, und Salinen-Wesen im Preussischen Staate, 22nd vol. 1874.

RUSSIA.—Native lead is found in several parts of Russia: in the Kirghis steppes in small plates, or grain embedded in hornstone, together with barytes and cerussite in the Bogoslowskoi mine, in the district of Karkalinsk; also in the gold washing of Katharinenburg and Tomilowskaja, and in the valley of the river Tomilowska.

SOUTH AFRICA.—Lead mining is not carried on extensively in South Africa. The ores are known to exist in different parts in the limestone formation extending from the junction of the Vaal with the Orange River in a north and then in an easterly direction to Rustenburg, in the north-west of the Transvaal. Many traces of native workings occur in these parts, and in one instance a deposit is being worked by an English gentleman, who smelts his own ore and disposes of his metal for local consumption amongst the farmers and hunters, who consume large quantities as ammunition.

LEAD, DESILVERISATION *and Softening of.*—In vol. iii. p. 71 the process of MM. PATTEN and ROUX, of Marseilles, was described. We have been favoured by M. ROZAN, of the firm of MM. LUCE and ROZAN, at Saint-Louis-les-Marseille, with the following statement of the continuation of that process by their firm:—

'The first results obtained by the process of desilverising by means of steam were published in 1871. By the publication now of the results deduced from the treatment of 22,000 tons of lead at 136 grams of silver, by average, per 100 kilograms of lead during the past five years, we propose to give a practical value to this process, which in 1871 might have been considered experimental.

'Since then the number of apparatus have been increased at our works from one to four, and we have put up—

2 Apparatus in the works of M. Roux at Carthagena.
2 ,, ,, ,, M. Figueroa, at Carthagena.
2 ,, ,, ,, Pontgibaud (Puy-de-Dôme).
2 ,, ,, ,, La Pise (Gard).
6 ,, ,, ,, Eureka, Nevada, Richmond County.
2 ,, ,, ,, Havre, Rothschild Frères.
6 ,, ,, ,, Newcastle, Cookson and Company.
2 ,, ,, ,, ,, Walkers, Parker, Walker and Company.
2 ,, ,, ,, London, Lead Company, Stanhope and Egglestone Works.
1 ,, ,, ,, La Spezia (Italy).
1 Now erected in the works of Messrs. Quirk, Barton and Company, Liverpool.

'*Description of the Process.*—Instead of stirring the melted lead during crystallisation with an iron paddle, as in the ordinary Pattinson method, or by means of iron flyers set in motion by steam, as in the Lavessière system, the direct agency of steam is employed.

'The steam, in escaping, produces in the mass a bubbling like that of very dense liquid in ebullition. This violent and continuous agitation is very favourable, as experience has proved, to the separation from the lead of the silver in the form of poor crystals and a rich liquid lead.

'The action of the steam is there essentially mechanical. In regard to its chemical action, although weak, for the reason that it has to deal with metals (lead, copper, silver, antimony) which do not decompose it at a temperature of about 330°, the point at which it is employed, it is nevertheless perceptible to some extent, since the lead is subjected during the operation to a softening independently of that which it undergoes during the fusion at red heat which precedes crystallisation. Previous calcining of indifferently hard lead is even dispensed with, that which is very hard being alone subjected to a preparatory calcining.

'If no chemical action of steam be supposed, the purity of the market lead, attained without previous calcining, might be attributed to the series of partial calcinings to which the lead is subjected during a great number of remeltings at red heat. But a fact which tends to show that the steam plays an active part in the softening, is that the skimmings which are produced, at first yellowish and earthy at the commencement of the operation (crystallisation), become, towards the completion, black and highly charged with copper. Towards the end of each operation, while the steam is still bubbling in the liquid, where, together with the silver, copper, antimony, and arsenic are concentrated, the lead is found more and more free from the copper it contained. In regard to the antimony, no such phenomenon is observed, but it is gradually eliminated during the successive meltings, in consequence of the oxidising action of the external air. It has even been noticed that soft leads yield a greater quantity of oxides than the hard, especially than the antimonial leads, and that too under the same circumstances, which proves that antimony, in combination with lead, is the first to become oxidised, and in measure protects the latter from oxidisation.

'In short, whatever explanation be given of the action of steam in softening, it is unquestionably certain and efficacious. It is a fact proved by experience that the market leads obtained by this process are perfectly soft, while the amount of silver contained varies from 1 gram to 2 grams at most per 100 kilograms. In rich lead ready for testing, the quantity of silver varies from 1,600 to 2,000 grams per 100 kilograms, according to the nature and richness of the lead treated. Although these contents may be reached in some works by the Pattinson process, we think their realisation, which has become practicable by means of the new process, can only be obtained by the old at the cost of a number of operations. The high content of the rich lead is not without its influence upon the total cost-price of the desilverisation, in comparison with the old system, as we shall show presently.

'In addition to the suppression of a special calcining, the employment of steam, as we shall describe it, offers several advantages, which we shall enumerate before proceeding to prove by figures.

'Diminution, and for Spanish leads suppression, of the expense of previous calcining.

'Less oxidation of the lead, and consequently diminution of expense and waste in the reduction.

'Only 156 kilograms of oxides, in place of 400 to 550, per ton of lead treated by the Pattinson method.

'*Economy of Time and Labour.*—This economy is due not only to the rapidity of the operation (crystallisation takes less time than in the Pattinson method; 20 to 21 tons instead of 9 to 10) and the reduced number of workmen, but also to increased rapidity in the separation of the lead into crystals and enriched lead, as shown by the following table:—

Successive Contents.

	Rich Lead	Always ⅓ and ⅔										Market Lead
Steam process . .	Grams per kilo. 1,000 to 2,000	1,000	550	300	170	85	43	23	12	6	3	Grams per kilo. 1½ to 2
PATTINSON process—rich lead, 1,150	875	500	290	153	120	70	45	26	13	7	4	2½
	⅞ and ⅛				⅓ and ⅔							

'The separation of the lead into crystals and into enriched lead is accomplished, for all the contents, in the new process by ⅓rd and ⅔rds.

'In the PATTINSON process, for contents above 120 grams per 100 kilograms, the separation was in the proportion of ⅞ths and ⅛ths; in order to have a sufficiently rich lead, ⅛th in crystals was put aside, the contents of which were the same as the original contents, and was therefore returned to the pot.

'We will conclude this enumeration by observing that the work at the apparatus requires less experienced workmen than the PATTINSON process, and thus insures to the factory owners a greater independence. Further, that the 10,000 to 12,000 francs of outlay for starting an apparatus are rapidly reimbursed, and that the buildings necessary for the new process are less extensive than for the PATTINSON system.

'In order to state precisely what one may expect in each particular case, we will here record certain observations relative to the influence which the nature of various leads has upon their behaviour during crystallisation. We know that a portion of the foreign substances (antimony, and especially arsenic) follows the silver and ends by partially taking its place. We may calculate that two-thirds of the antimony are eliminated in the form of an oxide, and that the remaining one-third is found in the lead ready for testing. In regard to the arsenic, the greater part goes to the enriched lead, where its influence is most hurtful in point of view of the enriching. The copper is almost entirely removed by oxidation. The following examples will show the importance of the effects due to impurities in the working of leads of various degrees of hardness.

'*Spanish Leads.*—Spanish leads contain rarely above ½ per cent. of antimony; about ¼ per cent. of iron, copper, and sulphur; traces of arsenic.

'These leads required formerly, before being subjected to the PATTINSON method, a previous calcining. The cost of the operations of previous calcining and refining, in consequence of having to reduce the oxides, amounted to 4 fr. 60 c. per ton. These leads, and even those produced by reduction of their skimmings in a reverberatory, pass at once to the apparatus. The only lead obtained by smelting in a blast furnace, the residues of reduction in reverberatory, is submitted to calcination, the cost of which is thus reduced to 95 c. per ton of lead treated.

'*Greek Lead.*—The leads of Greece contain—

Antimony	2·5 per cent.
Arsenic	1·0 „
Iron and sulphur	1·0 „
Copper	0·5 „
Total	5·0 „

Instead of 0·75 per cent. contained in the Spanish leads.

'The leads subjected directly to crystallisation give bad results, and a previous calcining is necessary. This operation should not be pushed as far as is required in the PATTINSON system. In order to obtain good results from crystallisation, the calcining should be stopped when the lead yet contains ½ per cent. of antimony.

'We have already remarked that the presence of a certain quantity of foreign metals (antimony, copper) was necessary to preserve the lead from oxidation during the remeltings at red heat and the crystallisings. It is from that fact that the twofold advantage already noted results: a diminution in the proportion of oxides; the suppression of the cost of previous calcining for lead which does not contain more than ½ per cent. of antimony.

'The Greek leads, even after calcining, cannot be easily enriched above 1,600 grams.

'*Pontgibaud Leads.*—The leads of Pontgibaud contain—

Antimony	3·2 per cent.
Copper	0·3 ,,
Arsenic	large proportion.

'These leads are subjected to a previous partial calcining, which eliminates a large portion of the antimony, but they present the same difficulties to their enrichment as do those of Greece. The rich lead does not contain more than 3 per cent. of antimony, like the rich Spanish lead, and yet cannot be made to give as high contents as the latter.

'If it be found that the arsenic is but very imperfectly eliminated in the reverberatory, it may be concluded from these facts that it is the arsenic which has the greatest tendency to take the place of the silver, and the influence of which upon enrichment is the most hurtful.

'It is evident, upon the whole, that the nature of the leads is not without its influence upon the labour, but, at the same time, that the advantages pointed out exist; some fully, because they are independent of the quality of the lead; others partially, since they lessen without destroying the bad effects due to the presence of antimony and arsenic.

'*Mode of Working with the Apparatus.*—Before explaining the details of an operation we will point out briefly the principal parts of the crystallising apparatus, the details of which we will describe according as the employment of the various parts presents them to our notice.

'An apparatus is composed of two pots placed upon different levels.

'1. The upper pot for melting the lead, with a capacity of 10 to 11 tons.

'2. The lower pot for crystallisation, with a capacity of 20 to 21 tons.

'A platform on a level with the edge of the lower pot permits the workman to remove the oxides and look after the progress of the operation.

'For running off the fluid contents of the pots, spouts closed by friction plates have been adopted.

'To prevent the lead penetrating the pipe by which the steam is introduced and there cooling, a valve is employed.

'The argentiferous lead being first melted in the upper pot, is skimmed and run off into the lower one. At the same time a small jet of steam is introduced, to facilitate the mixture of the crystals of the preceding operation with the melted lead.

'A slender thread of water thrown over the surface of the lead promotes its cooling and facilitates the formation of crystals. The steam produced by a boiler close at hand, and introduced, at a pressure of three atmospheres, into the lead bath by means of a lateral tube, is there distributed in a uniform manner, in consequence of the resistance offered to it by a cast-iron disk placed horizontally.

'The under pot is furnished with a cover in segments, which a workman removes alternately every four or five minutes to detach by means of an iron paddle the lead which may have come in contact with the cover, and there cooled during the agitation caused by the steam.

'Two small supplementary fire-places, which are set going a few moments before running off the fluid metal, serve to give the spout the desired temperature for flowing the lead.

'The workman removes the oxides once during each operation (at the commencement, before the steam is introduced).

'The segmentary cover has an aperture from which springs a chimney connecting the pot with condensing chambers, where the steam enters, carrying with it a portion of the oxides, which are there deposited in a pasty condition.

'The drawing off from the pot takes place when about two-thirds of the lead is crystallised. The enriched lead is received in cone-shaped moulds fixed in the ground. The spouts are furnished with gratings designed to arrest the crystals. Each block of lead weighs about 3,500 kilograms, of which two are made at each operation, that is to say, 7,000 kilograms, one-third of the contents of the pot.

'The blocks of lead, obtained successively in a series of operations, are removed by means of a steam crane, and ranged according to their contents around the apparatus, passing successively by rotation through the subsequent operations. The blocks of superior contents to those at the commencement are accumulated until their number allows a new series of operations to be commenced.

'The drawing-off accomplished, the lead which was melted in the upper pot, during the preceding crystallisation, is let into the lower pot.

'When the market lead or the complementary lead, which is in a crystallised state, is reached, fire is applied to melt it by means of the fire-grate of the lower pot. The market lead is cast in ingot moulds arranged in a semicircle, of which the spout is the centre, and filled by means of a gutter moving upon a pivot.

'The work done, taken together from the flowing of the lead from the upper to the lower pot, and the casting of the enriched lead into blocks, is called an operation.

An operation lasts from an hour and a half to two hours. The drawing off of the market and the complementary leads are reckoned as two operations, because the time requisite for the melting of the crystals in the lower pot is nearly double that required for crystallisation. The number of operations representing those drawings off is, for lead of 136 grams, from 25 to 32 per cent. of the number of crystallisations.

'The number of operations accomplished by an apparatus during twenty-four hours average fourteen, occasionally reaching sixteen and seventeen, according to the nature of the fuel and the proximity of the boiler.

'It is well known that the number of operations necessary for the treatment of the same quantity of lead varies with the contents. An apparatus treating lead at 136 grams produces, in a day's work of twenty-four hours, 10 tons of market lead.

'*Cost Price, at the St. Louis Works, of the complete Refining of Spanish Argentiferous Lead of* 136 *Grams per* 100 *Kilograms.*—We designate by refining the entire series of operations by which the argentiferous lead is transformed into—

Marketable refined lead,	Antimonial lead,
Refined silver,	Waste.

'We call lead treated in the year the quantity sent from the works under the various forms specified above. It is to that quantity that the year's expenses will relate.

'We give below a comparative table of the cost of refining lead by steam and by the PATTINSON system.

'The cost of refining by steam is deduced from the treatment of 22,000 tons of lead of 136 grams by average. That of the PATTINSON method is inferred from the work during one of the preceding years.

Expenses at the Apparatus shown per Operation.

Labour, special	Fr. 2.58
„ sundry	2.01
Fuel, 128 kilograms	3.85
Castings	1.09
Supplies	0.65
Cost per operation	10.38'

Désargentation et raffinage du Plomb au moyen de la vapeur d'Eau, M. L. ROZAN.

LEAD IN SEWING SILK.—The *Moniteur d'Hygiène* startles its readers with the revelation of an ingenious fraud, not generally known, but likely to be in the long run very dangerous to the health of tailors, sempstresses, and others who use silk thread in sewing. Nothing is more pernicious to the system than lead, and yet it may be constantly introduced into the stomach by those who use sewing silk. According to our French authority, certain manufacturers have adopted the plan of soaking their silk thread, of all colours, in acetate or sugar of lead, and exposing it after drying to the action of sulphurous vapour, which vapour, it is said, transforms the acetate into sulphate of lead, increasing the weight of the silk. The resulting gain may be imagined when we state that sugar of lead is worth considerably less than 25 cents a lb., whilst silk thread fetches from $10 to $11 a lb. in the market. It is alleged that some samples of silk have been proved to contain as much as 23 per cent. of sulphate of lead.

There is some mistake in the mode of stating the case, says the *Sewing Machine Gazette*, as the fumes of sulphur would certainly not convert the acetate of lead into sulphate. The fact of lead impregnation in silk is well known. The sugar of lead can be detected by the smell in some samples, not only in silk, but also in other thread, which is also sold by weight. Some adulteration, then, is practised, various matters being used to give weight to the articles; and, as a consequence, all thread rapidly deteriorates on exposure to the air. On this account the best sewing silk is usually well wrapped in wash leather.

It is easy enough to detect the adulteration by chemical process, and, although the result is not conclusive as to the presence of lead (as stated by the French writer), it proves at any rate the presence of some metal. Put a few pieces of silk thread at the top of a test tube, filled with water containing a few drops of acetic acid or vinegar. As soon as the silk gets moistened, let fall into the test tube a few drops of a solution of iodide of potassium. Then, if the silk contain lead or other metal, an iodide of the metal will be formed, sinking with a violet tint into the tube.

Several samples of silk thread have been tested in this manner. With the exception of one sample, all the fine sewing silk was proved to be free from lead or other metal.

But we found metal very abundant in what is called 'tailors' twist' and 'hatters' twist,' especially the latter.

The fact is important, if lead be the metal used for giving weight to silk. Lead acts very surreptitiously on the system; it is essentially 'a slow poison,' and it is very difficult to combat its effects. It acts on the teeth and on the intestines, in which it produces paralysis, frequently followed by death. 'We have seen,' says the writer in the *Moniteur d'Hygiène*, 'among other cases, that of a lady who keeps a large sewing establishment, who, by the use of such silk thread, was, together with her workwomen, attacked with a lead colic, some of them losing their teeth—the result of the habit of putting the ends of the silk into the mouth before passing it through the eye of the needle. Such is the way in which the lead poison is directly absorbed, whilst, by continually handling the silk, the fingers may retain a portion of the lead, to be indirectly introduced into the system with the food that may be touched by the hand. The poison may be avoided by refraining from putting the silk into the mouth—dipping it in gummed water instead: but perhaps the best remedy will be found by the large dealers refusing to buy silk thread by weight unless it is proved to be free from metallic adulteration.'

According to a recent writer in the London *Times*, the 'French dyers have attained such extraordinary skill, that they can colour up inferior qualities of silk so as to make them look far better than they are. In some cases they are able to charge the silk with lead and iron, which adds as much as 100 or 150 per cent. to the weight of it! All such artificial additions disappear when the tissue is exposed to any wear, however slight, and sometimes even when it is only exposed to the atmosphere.

LEAD ALLOYS, *comportment of certain, under the action of a reducing blowpipe flame on charcoal.*

Lead and tin unite readily, but the globule commences immediately to oxidise, throwing out excrescences of white and yellow oxide. On removal from the flame it still continues in ignition, and pushes out further excrescences.

Lead and bismuth unite readily, and the fused mass throws out excrescences, and becomes covered with a coat of oxide.

Lead and thallium form a malleable globule.—Chapman, 'On Blowpipe Reactions,' *Phil. Mag.*, December 1876.

LEAD, MOLYBDO, Arseniate of. See Achrematite.

Lead Exports in 1875:—

	Tons	Value £
Lead ore, to all countries	96	1,915
Pig lead "	24,271	537,562
Rolled and sheet piping and tubing, to all countries	11,127	282,541

LEAD, WHITE. *On the Manufacture of White Lead from Lead Ore containing Bismuth.*—The refined lead of the Upper Hartz is undoubtedly one of the purest now in the market. The entire amount of impurities does not exceed 0·2 per cent., of which two-thirds are composed of copper, antimony, silver, cadmium, zinc, iron, and nickel, while one-third (or, to be more accurate, 0·0075 per cent.) consists of bismuth. Since this last metal is the only one occurring in any noticeable quantity in the Hartz lead, it is no wonder that all the supposed failures of this last were ascribed to the bismuth. In particular, some white lead manufacturers asserted that bismuth imparted a tinge of grey to the carbonate made out of Hartz lead, which, it is true, disappeared after grinding and levigation; but the commercial white lead, when used as a paint, gradually turned yellow in the dark, which was not the case with other white leads—or, at least, not to such a degree. While such an action of bismuth on white lead was very unexpected from a theoretical standpoint, it still appeared advisable to ascertain by exact experiments whether it was true that oil-paints made of Hartz white lead turned yellow sooner than those made from other white leads, and whether this was due to the bismuth.

In order to attain this end, various foreign leads had to be converted into white lead contemporaneously with Hartz lead and alloys rich in bismuth, and under entirely like conditions; then these white leads had to be examined as to their properties and compositions. Mr. Von Dubbivelt, who has since died, superintended, with the greatest care and caution, the technical execution of the process, at the works of the Hartz Lead Works Company, at Osterode. For this purpose the company furnished about 5 cwt. each of Silesian (Tarnowitz) and Westphalian (Mechernich and Stolberg) leads. These, together with Lautenthal refined lead and bismuth alloys, prepared at the laboratory here, were converted into white lead under precisely similar conditions. When casting the leads into plates, average samples of each were taken for analysis.

After the first oxidation, the residual lead kernels were oxidised a second time, so that white lead and lead residues were obtained by a second oxidation. These last were also analysed, since the impression prevails in the factories that the foreign metals present in the lead are concentrated in these residues. The bismuth alloys were made by fusing the purest assay lead with bismuth, and were also analysed. They contained 0·1 and 0·04 per cent. bismuth, *i.e.* 15 and 6 times as much bismuth as the Hartz lead, while there were only traces of the remaining metals. All the analyses are combined in a table at the end of this memoir. They show, among other things, how variously the different white leads are composed. It must be remarked that the analyses of the foreign leads essentially represent the composition of the charges of 5 cwt., and not the average composition of the lead furnished by the different smelting works.

The appearance of the carbonate of lead obtained was varied. The bismuth alloys and the Silesian lead afforded a pure white carbonate, while the remainder had a perceptible greyish tinge. This greyish colour is probably due to the presence of finely-divided unoxidised lead, since it disappeared after grinding and levigation, and the white lead produced was of faultless colour.

Samples of all the various white leads were taken and mixed with the best oil in the proportion of 4 to 1, and then used as paints on glass and wood. These were carefully put away, to protect them from dust and light. At the end of 4 months all the paints had turned slightly yellow; those prepared from the bismuth alloys, the Hartz, and Silesian leads having undergone the least change. After 3 more months had passed, the yellowish tinges had perceptibly darkened; but there was no regularity as to the intensity of the present tinge compared to the former one, so that many of the paints had turned a deeper yellow than others which had been the darkest at the commencement of the 3 months. In many of the samples, also, the second products were less changed than the first had been. The samples painted on glass differed also very much from those on wood. It was, however, impossible to perceive that the samples prepared from Hartz white lead or from bismuthic white lead were a deeper yellow. It must also be stated that a portion of the Silesian white lead was mixed with antimony trioxide in the same proportion as that contained in the Hartz white lead, and then used as a paint. It was not found, however, that these oil-paints had turned a deep darker yellow than the samples prepared with pure Silesian white lead.

From these experiments it is shown in the most convincing manner that neither the presence of small quantities of intermixed foreign metals nor larger quantities of bismuth or antimony in the leads, although these pass into the white leads, promotes the turning yellow of the oil colours. This is merely due, as has been assumed for a long time, to the closing up of the varnish and resin whenever light is excluded. LÜDERSDORFF[1] has long since shown that the paints do not turn yellow if a solution of realgar in oil of turpentine and alcohol is used instead of linseed oil. The fact, too, that this tinge disappears in the light would seem to favour the idea of the organic nature of the colouring matter. All the paints which turned yellow reassumed their original white tint when exposed to sunlight for 24 hours.

Although the foreign ingredients of white lead do not promote the formation of this yellowish tinge, still hydrated lead oxide does. GRÜNEBERG[2] has called attention to the fact that white lead containing more hydrated lead oxide than corresponds to the formula

$$2\,(PbO,CO^2) + PbO,HO = \left.\begin{matrix} Pb'' \\ 2\,CO \\ H^2 \end{matrix}\right\} O^6,$$

when mixed with oil, turned yellow after a few hours. Pure hydrated lead oxide, mixed with linseed oil and varnish, made a good covering paint, which, when kept in the dark, turned lemon-yellow at the end of 48 hours. It may easily be ascertained, by means of turmeric paper, whether a white lead is more basic than the above compound; for if the paper is turned brown by the filtrate after washing the white lead, there is free hydrated lead oxide present. This can readily be removed by levigation with a little acetic acid.

When, however, the above-mentioned white lead does react on turmeric paper, and yet gives oil-paints which gradually turn yellow, the reason for the lack of uniformity in the intensity of the yellow tinge may, perhaps, be in some way connected with a somewhat varying quantity of carbonic acid. The intensity of the yellow tinge will then be dependent on the nature of the varnish and basic nature of the white lead; in no way, however, on the slight quantities of foreign ingredients. These are, indeed,

[1] *Journal für Praktische Chemie*, vol. vi. p. 137.
[2] *Polytechnisches Centralblatt*, 1860, vol. xxvi. p. 1104.

as little in fault as they are in the case of the rose-colouring of the white lead, which was attributed to copper, silver, and even to iron, until BARROW and KRÄMER[1] showed that it was due, not to these metals, but to a badly-conducted corrosion of the lead, in which there was an insufficient access of air, causing the formation of lead suboxide, which then imparted a rosy tinge to the white lead.

The frequently-observed rapid corrosion of lead pans for evaporating sulphuric acid was in the same way attributed, without any reason, to the presence of foreign metals. HASENCLEVER[2] showed, however, that it was due to the great purity of the refined lead. Antimonial lead lasted much longer than the other.

Finally, with regard to the frequently-imputed enrichment of the foreign metals in the metallic residues (the so-called lead kernels) obtained in the preparation of white lead, it is impossible to give a definite answer to this from the following analyses. It must, however, be borne in mind that such pure leads are not well adapted to settle this question, since the differences are so small that it is impossible to say whether they are essential, or whether they are due to the uncertainty caused by the taking of the samples for analysis from the residues. An enrichment of the bismuth in the finely-divided lead was found only in the bismuth alloys, after separating the residues from the white lead by washing. Alloy I. contained 0·1 per cent. bismuth, and the metal obtained by washing the white lead contained 0·141 per cent. Alloy II. contained 0·0416 bismuth, the residues 0·0574 per cent. This had a peculiar, distinctly crystalline texture, and broke easily.

TABLE OF ANALYSES.

Hartz Lead.

Ordinary Hartz white lead obtained from the factory:—

	Per cent.		Per cent.
Bi	0·004541	Fe	0·002100
Cu	0·001708	Zn	0·000305
Sb	0·001236	Ni	trace
Ag	0·000500		

	Original Lead from Lautenthal	White Lead from I. oxidation	White Lead from II. oxidation	Lead residues from II. oxidation
	Per cent.	Per cent.	Per cent.	Per cent.
Bi	0·008498	0·006276	0·008275	0·011091
Cu	0·000954	0·000431	0·000447	0·001149
Sb	0·001180	0·000903	0·001156	0·001139
Ag	0·000500	0·000500	0·000500	not determined
Fe	0·004930	0·000728	0·000660	trace
Zn	0·000361	0·000128	0·000176	
Cd, Ni	trace	trace	trace	

Silesian Products.

	Original Lead	White Lead from I. oxidation	Lead residues from II. oxidation
	Per cent.	Per cent.	Per cent.
Bi	trace	trace	trace
Cu	0·0012	0·000566	0·000938
Cd	0·00016	0·000390	0·000500
Sb	0·00131	0·000444	0·001388
Ag	0·000166	0·000130	0·000168
Fe	0·00120	0·000903	0·000360
Zn	0·00035	0·000257	0·00031

[1] *Berlin Deutsche Chemische Gesellschaft*, 1872, No. 12, p. 545; also *Berg- und Hüttenmännische Zeitung*, 1872, No. 30, p. 126.
[2] *Polytechnisches Journal*, 1872, vol. ccv. p. 125.

Mechernich Products.

	Original Lead	White Lead from I. oxidation	Lead residues from II. oxidation
	Per cent.	Per cent.	Per cent.
Bi	0·00022	0·000197	0·00024
Cu	0·00051	0·000408	0·000111
Cd	0·00037	0·000200	0·000450
Sb	0·00320	0·002218	0·00310
Ag	0·00032	0·000300	0·00038
Fe	0·00075	0·000937	0·000634
Zn	0·00032	0·000337	0·00020

Stolberg Products.

	Original Lead Per cent.		Original Lead Per cent.
Bi	0·000966	Ag	0·00055
Cu	0·00110	Fe	0·00066
Cd	0·00056	Zn	0·00050
Sb	0·04921		

Bismuth Alloy I.

	Original Alloy	White Lead from I. oxidation	Finely-divided Lead obtained by levigation after I. oxidation
	Per cent.	Per cent.	Per cent.
Bi	0·100000	0·078507	0·141
Cu	0·000626		
Sb	0·000224		
Fe	0·000443		
Zn	0·000804	not determined	not determined
Ag	0·000050		
Cd	0·000802		
Ni	0·000052		

Bismuth Alloy II.

	Original Alloy	White Lead from I. oxidation	Finely-divided Lead obtained by levigation after I. oxidation
	Per cent.	Per cent.	Per cent.
Bi	0·041640	0·0286	0·0574
Cu	0·000626		
Sb	0·000224		
Fe	0·000443		
Zn	0·000804	not determined	not determined
Ag	0·000050		
Cd	0·000802		
Ni	0·000053		

—Dr. W. Hampe, of Clausthal, 'On the Adaptability of Lead containing Bismuth for the Manufacture of White Lead,' *American Chemist.*

LEATHER. The following particulars, relative to the manufacture of sole leather in Bristol, are chiefly derived from a paper read by Mr. Stark Evans, of the Avonside Tannery.

In Bristol there were, in 1816, 9 tanneries; in 1875 there were 13. Bristol possesses many advantages, from its proximity to oak woods; and the practice of allowing a long time for tanning in the tanneries of that city is proved to be of great advantage in the increased wear of the leather produced.

The growth of commerce occasioned such a demand for hides, they would have become of extravagant value, but for the introduction of South American hides and Turkish *valonia.*

South American hides were first introduced into Castile in 1580.

The number of dry and salted hides imported from South America, according to Mr. Spark Evans, was, in 1872, 3,121,758. The Board of Trade returns are as follows:—

Hides	1872	1873	1874	1875
	Cwt.	Cwt.	Cwt.	Cwt.
Not tanned, tawed, curried, or in any way dressed. Dry . .	808,420	626,274	554,167	552,292
Do. wet	627,030	713,099	710,107	655,104
	lb.	lb.	lb.	lb.
Tanned, not otherwise dressed .	23,574,061	28,671,458	26,791,060	36,409,359
Tawed, curried, or in any way dressed, not being varnished, japanned, or enamelled . .	3,135,162	2,484,668	4,492,235	5,297,680
Varnished or enamelled . .	479,658	461,870	328,843	457,898

It is a curious fact that the loss occasioned by branding to prove ownership is estimated at 300,000*l.* yearly. The pickling of hides has been very usually practised on the voyage; but it is strongly objected to, and thus it is likely to cure itself.

Messrs. Cortheus and Pullein have introduced a mode of suspending hides in lime, thus unhairing them in four days without heat. The cool-sweating process used in America is not employed in Bristol; neither is the sulphide of sodium or the charcoal process in use. All patent processes are said by Mr. Spark Evans to have failed for tanning. Rapid processes are considered objectionable, twelve months at least being required to make thick leather both pliable and impermeable.

Kip Tanning. (Kips are the hides of young cattle.)—Imports are estimated at 7,000,000. The average amount of plaster adulteration on each kip, 1½ lb.

The waste products of a tannery are usually turned to good account. Untanned portions of the hide are sold for sizing paper and the manufacture of gelatine. Hair is now largely used in the manufacture of cheap clothing, blankets, and imitation of seal skins. Spent tan is burnt for its ashes: lime deposit is used as a manure.

The tanning materials used in Bristol are:—

	Native Production	Value £
Oak bark	—	—
Valonia	24,434 tons	622,019
Myrabolanes	321,334 cwt.	196,122
Mimosa, Terra japonica, Divi-divi	Grouped under Tanning and Dye Drugs in the return	
Hemlock extract	—	—

Tannometer.—Dr. John Watts gives the following account of Muntz and Ramspacher's apparatus for the estimation of tannic acid. By this may be determined the actual leather-producing power of an astringent substance, which, according to the experience of the manufacturer, does not appear always to coincide with the percentage of tannic acid.

The apparatus may be briefly described as a shallow gun-metal drum of about 200 cubic centimètres capacity, permanently closed at one end by an india-rubber plate, and capable of being closed water-tight at the other by a piece of depilated hide when clamped upon a stand over which the hide has been previously stretched.

The drum is perforated at the side with a screw to admit of the introduction of the tanning liquor, and is fitted above with a screw piston to compress the india-rubber disk. When the piston is lowered the liquor is forced through the hide, while the latter retains the whole of the tannic acid. The density of the liquor is taken before and after the operation by means of a very fine hydrometer graduated to a special scale, when the difference expresses at once the percentage value of the liquor operated on.

In order to compare the results of this tannometer with Hammer's table of percentages of tannin in solutions of different densities, and to compare both with the results of evaporation, a number of experiments were undertaken by the inventor. The percentages only indicate the value of the particular sample under examination. The numbers in the first column were obtained by taking the specific gravity at 15° before and after removing the tannin and obtaining the percentage equivalent from Hammer's table. The third column was found by evaporating 25 cubic centi-

mètres in a platinum dish before and after the removal of the tannin and drying the residue for three or four hours at 100° C.—*Ann. Chim. Phys.* 1875. *British Association Report*, 1875, p. 47.

	By Specific Gravity	By Tannometer	By Evaporation
Cube gambier	41·45	40·44	47·43
Bale gambier . . .	42·44	39·50	49·02
Catch	47·70	44·60	52·16
Valonia	25·32	25·32	26·30
Myrabolanes	32·30	30·25	31·08
Mimosa bark . . .	31·44	30·18	31·72
Blue galls	60·60	59·10	—
Green galls	53·40	52·41	57·90
Sumach	17·10	18·00	19·55
Divi-divi	34·50	33·94	35·20

Leather, Fastening of, to Iron.—The American manufacturer recommends that a quantity of nut-galls, reduced to powder, should be dissolved in eight parts of distilled water, and after remaining for six hours should be filtered through a cloth; and the decoction thus produced applied to the leather. Take the same quantity of water as that used for the nut-galls, and place in it one part (by weight) of glue, which is to be kept warm for twenty-four hours and then applied to the metal, which should first be roughened and heated. The leather is then laid upon the metal and dried under pressure. The permanence of this is said to be something remarkable.

Leather Exported in 1875.

		Value
	Cwt.	£
Tanned, unwrought	168,147	1,495,831
	Dozen Pairs	
Wrought, boots, &c.	462,840	1,517,267
	Lb.	
Wrought, unenumerated	1,879,560	382,987

LEATHER, VEGETABLE.—Sheets of carded wadding are manufactured with cotton waste or cotton itself, according to the quality required to be produced, uniform in thickness, length, and width, which sheets are placed on polished zinc or other metal plates, then the wadding is coated with a concentrated decoction of *fucus crispus* or pearl moss, or other fucus or mucilaginous lichen (rock moss), or any similar mucilaginous substance may be employed. The metal plates require to be kept hot, in order to allow the mucilaginous decoction to penetrate thoroughly into the filaments of the cotton. The sheet is then dried quickly, thus giving to the surface applied to the metal plate a glazed or polished appearance resembling the gloss of ordinary leather. The sheet thus prepared is passed between two heated cylinders or rollers perfectly polished, having a space between them the exact thickness required to be given to the sheet to be produced. Great pressure is required in order to press and felt all the filaments of cotton thoroughly together, and thereby render the thickness of the sheet uniform. The sheet is then coated with boiled linseed oil and dried in the open air, or by means of artificial heat. When the sheet is dry a coating of thin vegetable wax is applied, according to the use to which it is to be applied, and the sheet is softened by passing it through heated fluted rollers, by which means it is softened in a uniform manner; it is then passed through other polished rollers, according to the quality of the leather required, either plain, morocco, embossed, glazed, or otherwise, and it is then bronzed, silvered, gilded, or varnished, and finished in like manner to ordinary leather. French, vegetable, or similar leather thus prepared is waterproof and easily stamped.

Elasticity is given to vegetable leather thus produced by placing the sheets impregnated with the decoction of fucus, or other mucilaginous substance, between two plates perfectly adjusted, having the design embossed or in intaglio. Great pressure is then applied to the plates, and the dried sheet is then passed through rollers, which, by flattening the embossed parts, form a smooth surface, which is then treated as above stated, and becomes elastic after the oil is dry. Pressure may also be successfully applied before the leather is impregnated with the siccative oil. The material can be made perfectly white by selecting very white fucus and by bleaching the oil

to be used: various colours from the lightest to the darkest may be obtained by using the proper pigments. If the leather thus produced is required to be inodorous, it is only necessary to wash the oil in a weak solution of chloride of lime. A method of preparing vegetable leather of this character for use, as cheap sole leather, consists in thickening the decoction of fucus or mucilaginous lichen with cotton waste or dust until it becomes a thick paste. The paste is then run into moulds or blocks, and is pressed by means of an hydraulic press, in order to form solid blocks of any suitable thickness, which are then dried and cut by saws into plates or sheets of the ordinary thickness of sole leather. These plates or sheets are then soaked in boiled linseed oil, and when dry are pressed again between polished metal plates.

LEUCITE. (Vol. iii. p. 107.) See LAVA.

LIGNITE. *On the Production of Compressed Fuel from Earthy Lignite in Prussia.*—The lignite beds of the North German plain, although at times of great thickness (occasionally 100 feet), are mostly of the earthy or 'moor coal' variety, which, although possessed of a certain amount of cohesion when freshly raised, generally breaks up to dust and slack on drying; and even in the more favourable deposits, yielding more compact minerals, the proportion of round coal rarely exceeds 30 to 40 per cent. of the total output. The economic value of such a material being exceedingly small, it was at one time customary to leave the greater portion of the produce of the lignite mines upon the waste heaps, or even underground, the large coal alone being saleable. The rapid increase in the prices of better descriptions of fuel has, however, led to the trial of various methods of compressing the slack with a view of obtaining coherent masses that can be burnt in an ordinary grate. These experiments, which have been principally carried out in the manufacturing districts of Prussian Saxony, have resulted in the development of a new branch of mineral industry, which is described in detail by the author, who classifies the various methods adopted into three, namely:—

1. Hand moulding.
2. Wet coal pressing by machinery.
3. Dry coal pressing by machinery.

The first of these methods, the oldest and most imperfect, is nothing else than the ordinary hand brick-making. The slack, as raised from the mine, is mixed with sufficient water to form a plastic mass, which is then formed into bricks in open wooden moulds upon a table in the usual way. The dimensions generally adopted are about 8 by 4 by 2½ inches, four bricks being moulded at a time. About 15 per cent. of water is added to the slack, which generally contains from 40 to 45 per cent. of mine water, making from 55 to 60 per cent. of moisture in the bricks as freshly moulded. From twelve to fourteen days' exposure, according to the state of the weather, is required to render the bricks completely air-dried and fit for use, in which condition, however, they still retain from 32 to 36 per cent. of water. The average compression in volume, as compared with the raw coal, is 36·4 per cent., and the specific gravity of the dried mass is 1·2707. A very large proportion, however, of the production, sometimes as much as 25 per cent., is broken in drying and handling, owing to the numerous fissures formed as the water evaporates, as the mass does not contract as a whole. The average selling-price of hand-moulded bricks of this kind is from 7*s*. 10*d*. to 8*s*. per thousand; the maximum number that can be produced by a rough workman per twelve-hour shift is about 1,200, which includes both the preparation of the mass and the conveyance of the bricks to the drying place.

Wet Coal Pressing Machines.—The first attempts at substituting machinery for hand moulding were made about thirty years since, when several different patterns of machines, such as were then in use for brick-making, were tried. These experiments were for the most part failures, owing to the adoption of closed moulding tables,[1] which, although well adapted for making bricks from moderately dry clay, were not suited for a material of an imperfectly plastic character like wet coal-dust. The newer machines have, therefore, been mainly of the continuous class; the coal, after being finely divided by passing through rollers, is mixed up to a uniform paste in a pug mill and moulded by pressure through a die-plate or mouth-piece of rectangular section, whence it passes out in a continuous stream and is cut into pieces of the proper size by a frame carrying strained steel wires, which is made to traverse the mass at proper intervals. A principal defect in these machines is the tendency of the coaly mass to adhere to the cast-iron die-plate, so that it was scarcely possible to deliver the moulded mass in lengths of more than about 20 inches without breaking. This was partially obviated by coating the mouth-piece with leather, a plan that proved moderately successful with the bituminous kinds of lignite, but was unsuited to the drier and less plastic varieties. About 1863 a more efficacious method was introduced by Mr. L. SCHMELZER, of Magdeburg, who, having observed that the wet lignite mass separated more readily from heated than from cold metal, substituted for

[1] Like those of BRADLEY and CRAVEN'S, and similar semi-dry clay brick machines.—H. B.

the original cast-iron die a slightly conical mouth-piece in bronze or copper, with hollow sides, which is kept heated to about 100° Centigrade by a current of waste steam from the engine driving the press.

The machine so modified, with some further improvements in the cutting frame, is known as HERTEL-SCHMELZER's coal press, and has completely superseded the older patterns. It consists essentially of a horizontal mixer and pug mill, with screw mixing blades, which receive the moistened coal from two pairs of crushing rolls placed one above the other, the lower pair being set to crush all particles to a uniform size of 3 to 4 millimètres. The mixing and pugging apparatus is 23·6 inches in diameter at the feed end, and diminishes to 20·7 inches at the delivery end, and the aperture of the mouth-piece or die, which is of rectangular section, with the corners slightly rounded, is 9 inches by 3·8 inches, corresponding to the length and breadth of the finished blocks. The delivery table and cutting frame is very similar to that of a CLAYTON brick machine.

These machines are made in three sizes, the smallest producing 12,000, the middle size 20,000, and the largest up to 40,000 blocks the shift of ten hours with coal of suitable quality. The amount of breakage with the larger machine is about 2,000, or from 5 to 6 per cent. of the total produce. The power required is from 10 to 20 horse-power, according to size, the principal portion of which is required by the pug-mill shaft, which makes from fifteen to twenty revolutions per minute. About 5 to 10 per cent. of water is added to the wet slack as raised, or somewhat less than is required in hand moulding, the total amount of moisture in the mass as it leaves the press being from 50 to 52 per cent.

The blocks as delivered from the machine are received upon boards and loaded on to light waggons made of flat and angle-iron bars, carrying 216 bricks up three platforms, and removed to the drying place. The drying may be effected in the open air in summer, when the weather is favourable, but as a general rule drying sheds are preferred. When it is intended to carry on the process in wet weather, artificially heated and closed drying-chambers are necessary. As a rule, from eight to ten days are required for drying, the loss of weight averaging 24·88 per cent., so that in an air-dried condition the moulded blocks contain 28 per cent. of water. The specific gravity is 1·298, and the amount of compression in volume, as compared with the raw coal, about 50 per cent. It has been found by experiment, made at the salt works of Durienberg, that pressed blocks, when applied in boiling down brine, have a heating power about 11 per cent. greater than those moulded by hand. But in order to obtain manageable fuel it is found better not to push the drying too far, as the best effect is got with those containing 40 or 41 per cent. of water, which stand the fire better and do not break up and pass through the bars unconsumed to the same extent as those that are completely dried. For the same reason blocks that had been kept in store for some time were found to be of somewhat increased strength, having absorbed moisture from the atmosphere.

The cost of the complete plant for wet coal-pressing, including engines, boiler, drying-sheds, &c., is from 2,000*l.* to 2,100*l.*; representing, at 10 per cent. for interest and sinking fund, about 210*l.* per annum, but chargeable upon the actual working season, which for most of the pressing establishments is about 130 days, or about 1*l.* 10*s.* per diem. The cost of production of 35,000 blocks daily is about 4*l.* 10*s.*, or 2*s.* 7*d.* per thousand; the average selling prices are from 11*s.* to 14*s.* per hundred.

Dry Coal Pressing.—The first experiment in the production of moulded blocks from dry lignite, analogous to those made from coal slack, were made by the SAXON-THURINGIAN BROWN COAL COMPANY in the year 1858, and about the same time works for carrying out the process were erected at several mines in the district of Magdeburg. Since that date the manufacture has been considerably extended, and is still progressing. The process is based upon the property possessed by the earthy brown coals of becoming coherent masses when subjected to considerable pressure when finely powdered and completely deprived of hygroscopic water.[1] In order to obtain a product of uniform quality, it is essential that the particles operated upon should be uniform in size and as completely dried as possible, which involves the operations of sizing and grinding, and artificial drying preliminary to the actual moulding or pressing.

The first of these is to a certain extent optional, although the author considers that it does not always receive sufficient attention. In some cases the coal as raised is charged directly into the ovens, in which state it is almost impossible to dry it thoroughly. Otherwise it is passed over sieves of from 5 to 10 millimètre mesh, in order to separate the larger pieces. Both rotary and plain sieves are used—the

[1] This property is analogous to that of the asphaltic limestones of Savoy and Switzerland, which disintegrate when heated, but can be completely consolidated by subjecting the powder to a moderate pressure at a temperature of 120°.—H. B.

latter being best adapted for the more cohesive or 'smeary' coal, as they can be more readily cleaned. When the sifted coal is not sufficiently small it is passed through crushing rollers, or in one instance, at a mine in the province of Brandenburg, ground in a CARR's disintegrator. The latter machine the author considers preferable, as, by passing heated air through, the material may be partially dried during the grinding. In some works the crushing takes place after the coal has passed once the drying oven, and is subjected to a second drying when crushed, but this is generally considered to be an unnecessary complication.

The second operation, that of drying, is the most difficult part of the process, and a large amount of ingenuity has been displayed in the construction of ovens for this process. These may be classified, according to the method of heating, into steam and hot-air ovens, and, further, according to the means adopted for passing the coal through into mechanical and gravitating ovens. In the former class special arrangements, such as stirrers or screw creepers, are required to move the material upon horizontal surfaces of exposure; while in the latter it is passed from above downwards through tubular chambers by a system of inclined distributing blades. The simplest and oldest form of oven is that heated by steam, with mechanical stirring arrangements. This, as now constructed, consists of ten hollow steam-heated horizontal discs, of wrought iron, 12 feet in diameter, placed parallel to each other, at vertical distances of 17·7 inches apart, so that the height of the oven is from 16½ to 18 feet. The discs are supported by brackets between four cast-iron columns, two of which form the admission and exhaust channels for the steam. Openings, placed near the centre and circumference alternately, are made through the discs, so that the coal spread on the first disc is drawn towards a central hole and discharged to that next below, where it is spread out and dropped through holes near the circumference to the third, which discharges at the centre, and so on to the bottom. The transfer is effected by scraper arms attached to a central vertical shaft, which receives a slow movement of rotation from a steam-engine by bevel gearing. Formerly the discs were enclosed in a wrought-iron cylinder, and movable, the scraper arms being fixed, after which the latter were made movable, but the cylinder was retained. This form of oven has, however, been abandoned, on account of the difficulty of getting at the interior for repairs; and they are now made without any casing, a plan which the author considers objectionable, on account of the annoyances caused by the dust from the stirrers, which not only clogs up the working parts of the press, but is a very inflammable material. He therefore suggests that in all cases the oven should be placed in a closed chamber. The oven is usually heated by waste steam from engines, so that the temperature attained is rarely above 176° Fahr. With two revolutions of the stirrers per minute the coal remains about fifty minutes, retaining from 25 to 30 per cent. of water, and must be passed through a second time before it is fit for pressing, a circumstance which sufficiently accounts for the small amount of work done, namely, 512 cubic feet of coal dried in the twelve-hour shift, or about half the quantity required to keep a press employed during the same time. It is usual, therefore, either to have a second oven, somewhat smaller, with 10-feet instead of 12-feet discs, and working more quickly for the final drying; or the same oven is worked night and day, while the pressing is confined to the day shift.

JACOBY's tubular oven is another kind of steam-drying oven, in which the distribution of the wet coal is effected by gravitation. This consists of twelve parallel horizontal pipes, united at regular vertical intervals by outside bands into a coil similar to that of the Westphalian hot-blast stove, which is enclosed between longitudinal walls, forming a narrow rectangular chamber about 10 feet high, 5 feet long, and 1½ feet broad. The pipes are of an irregular pentagonal section, and present a central ridge along the axis of the oven, upon which the coal, fed in by a hopper, falls, and is diverted onwards, to be received in a second hopper below, which distributes in the same way upon the ridge of the next pipe below, and so on to the bottom. Under each line of steam-pipe run rectangular chambers, with perforated sides, receiving a current of heated air from a fan, which is blown through the coal and assists the drying.

The breadth or thickness of the layer of coal in contact with the heated surfaces is about 2½ inches. The discharge is effected by a curved spreading plate, mounted upon a radial arm, which receives a slow reciprocating movement, which can be varied so as to keep the coal a greater or less time in the oven. Under the ordinary conditions of using waste steam, both for the presser and for heating the air blast, the temperature obtained in the oven does not exceed 158° Fahr., or 176°; and consequently it is exceedingly slow in action, the wet coal remaining in it for four hours before it is sufficiently dried. Ten ovens of the dimensions given above are required to supply coal for one press. They are placed parallel to each other and 20 inches apart, in an

enclosed chamber, which has an inclined floor, with a receiving hopper behind, for each pair of ovens. These hoppers are in connection with a screw creeper, which carries the dried coal to the press. The principal advantage as compared with the disc oven is that, with the exception of the discharging apparatus, there are no moving parts, and the feed is automatic, so that, if the supply is well kept up, the work goes on regularly, and the cost of repairs is small. The first cost is, however, very large (from 3,500*l.* to 4,000*l.*), and therefore in the newer establishments all forms of steam-heated stoves have been abandoned in favour of the less complicated and more efficacious plan of drying by heated gases. The oven known as RIEBECK's trough oven contains a series of 32 horizontal wrought-iron troughs, with semi-circular bottoms, arranged in a heated chamber. Each trough contains a screw scraper, which moves the coal introduced at one end slowly forward, and discharges it at the other into the next trough below, where it receives a similar motion in the reverse direction, and so on through a third and fourth, when it is received in a collecting trough running along the front of the chamber. This apparatus, besides being exceedingly costly, has proved difficult to manage and keep in repair, so that only 3 are now actually in use. The second, or RIEBECK's plate oven, is similar in form to the steam disc oven previously described, circular plates of wrought iron being substituted for the hollow steam-heated discs. Originally as many as 21 plates were used in each oven; but they are now generally made with only 12 or 15, that number being found to give a sufficient supply of dried coal for a single press. The outside diameter of the disc is about 13 feet, and their vertical distance about 12 feet. The arrangement for passing the coal from above downwards, by stirrers attached to a central shaft, is generally similar to that in the steam disc oven; but in the newer modification the discharge takes place over the outer and inner circumference of the plates alternately, instead of through holes or slits in the bottom, so that the receiving plate has the rim turned up to prevent the coal as it falls from spreading too far inward or outward respectively. The whole apparatus is enclosed in a rectangular chamber of brickwork, which is maintained at a uniform temperature of about 260° by a current of heated gases from a special fire-place, which convey it at 400° to 450°, and leaving the chamber at 100° or 150°. The coal containing 45 per cent. of water is dried to 15 per cent. in one hour's exposure; so that an oven of moderate dimensions does a considerable amount of work. This, together with the small first cost of 450*l.* and the moderate consumption of fuel, has led to the general adoption of this oven, in spite of the great drawbacks caused by the difficulty of getting at the interior for small repairs, and the extreme care required in feeding, which, if neglected, gives rise to the danger of the coal firing or becoming useless through over-heating. Great care is also necessary to prevent the access of air to the heated chamber; and the author recommends as a useful precaution that one or more steam pipes should be connected with the oven, for the purpose of smothering fire in the event of the coal being ignited through over-heating.

In LEUTERT's chamber oven, which, although of recent introduction, appears to possess considerable advantage over the older pattern, the coal is dried by passing it downward in a thin stream through a heated chamber, the distribution being effected by a series of angle-iron spreaders, resembling ladders with inclined steps or louvre-faced ventilators, which break it up into narrow zigzag streams, the action being similar to that of the JACOBY oven, but attained by much simpler means. The apparatus consists of a rectangular block of brickwork, about 28 feet long, 26 feet broad, and 25 feet high, which is divided by internal walls into 4 oblong chambers, each of which contains 4 pairs of spreading bars or ladders. These are united in pairs by a common discharge apparatus, which consists of an oscillating spreading plate, which may be moved faster or slower according to the time that it is desired to keep the coal in the oven, and a screw creeper. The interior of the chamber is maintained by fire gases at 180° or 200°, which are introduced through special flues, so arranged that one or more divisions may be shut off without stopping the others. Two out of the four series of chambers of an oven of the above dimensions, working continuously through the twenty-four hours, are found sufficient to keep a press fully employed.

The consumption of fuel in drying varies with the different classes of oven, being greatest in the trough ovens, which burn about 11 per cent. of the volume of coal dried, while in the disc and chamber ovens it averages about 5 per cent.

Dry Coal Pressing.—The press used for moulding the oven-dried coal into blocks is a modification of that introduced by EXTER for the manufacture of peat fuel in Bavaria, which has completely superseded those of other patterns. This is essentially a horizontal reciprocating plunger, moving in a steel-lined press tube which forces the dust coal, fed through a funnel at one end, through a mould formed of two adjustable dies at the other, the amount of pressure applied being regulated by the opening of

the dies. The press makes 60 strokes per minute, producing an equal number of blocks, which are 160 millimètres long, 70 millimètres broad, and 30 millimètres thick, the ends being slightly rounded; the two former dimensions are those of the die, while the last represents the length of stroke of the press. Originally it was considered necessary to press the coal at a comparatively high temperature (40° to 50° C.), but since 1864 it has been found that the quality of the product is much the same when pressed cold; so that the older practice has been given up, as it was a source of additional expense, besides causing an extra amount of dust in the press house. A certain substitute has, however, been made in the use of steam for heating the head of the press ram, which gives a smoother and better-finished look to the product.

In either case, however, a large amount of dust is produced, which not only clogs up the machinery if allowed to accumulate, but is dangerous from its ready inflammability. It is necessary, therefore, to keep the machinery constantly cleaned, and to use good liquid lubricating materials, besides sprinkling the floor of the press house with water at least once daily. When working with artificial light, locked lanterns are used, taking air from and discharging their smoke to the outside of the building.

The number of blocks made by a single press in the shift of twelve or ten working hours is 36,000; but as most of the drying ovens are in continuous action, the work of pressing goes on day and night. For the production of 1,000 blocks, 7·5 hectolitres of coal of 561 kilograms wet weight are required, which is reduced in the finished product to 3·23 hectolitres, or 56·5 per cent. in volume, and 375 kilograms, or 33½ per cent. in weight. As, however, 18 to 20 per cent. of water is retained, only 26 per cent. of the above amount represents the actual evaporation, the remaining 7½ per cent. being lost by decomposition, by heating, and as dust and leakage in the pressing. The specific gravity of the pressed blocks is 1·20 to 1·22, or somewhat less than that of natural air-dried lignite. They are very solid, and bear transit without breakage, being especially in demand for domestic purposes; the selling price is about 6s. or 6s. 6d. per thousand.

The cost of a well-arranged press and drying oven, with the necessary engines and boilers, is at least 6,000*l.*, corresponding at 10 per cent. to a charge for sinking fund and interest of 2*l.* per working day, or 1*l.* per 36,000 blocks produced. The cost for labour, fuel, and materials brings up the producing price of the above quantity to 3*l.* 2*s.*, or about 1*s.* 10*d.* per thousand. Where two or more presses are in use the cost is considerably less, as the establishment charges are no greater than for a single one.

The general properties of the different classes of fuel previously described are summed up in the following table:—

	Wet Coal as raised	Hand-moulded Blocks	Wet-pressed Blocks	Dry-pressed Blocks
Specific gravity . .	1·22– 1·29	1·24– 1·31	1·26– 1·32	1·20– 1·22
Proportion of water per cent. . . .	42·30–47·00	32·10–35·40	26·60–30·00	17·20–21·60
Proportion of ash per cent. . . .	6·00– 9·30	7·70–13·80	8·60–10·50	10·00–14·20
Heating power . .	183–209	179–223	231–287	233–315
Stability . . .	—	0·17– 0·22	0·38– 0·45	0·68– 0·74
Condensation in volume per cent. . . .	—	36·4	50·1	56·6
Value per 1 hectolitre of coal used . .	*d.* *d.* 1½–2½	*d.* *d.* 3–3½	*d.* *d.* 4½–6¼	*d.* *d.* 6¾–7½

The older method of hand moulding has, during the past six years, to a considerable extent been replaced by presses. In 1870, in the district of Magdeburg, about eight million blocks were made by the former, and seven million by the latter method; but in 1873 the proportion was changed, eight millions being hand, sixteen millions and three-quarters being machine made. In 1875, 60 wet and 27 dry presses were erected, of which an average of 77 were at work, and converting nearly 500,000 tons of lignite per annum into blocks. In the whole of the Prussian dominions there were in the same year 106 presses, 73 wet and 33 dry. The greater proportion of the former as compared with the latter is to be attributed to the smaller first cost, which makes them better suited to the means of the mine owner. Of the two classes of blocks, the wet-pressed are in somewhat larger demand, which the author attributes to their being comparatively cheaper for an equal amount of useful coal than the dry-

pressed; 1 ton of useful coal, *i.e.* after deducting that required for the evaporation of the contained water, costing 17*s.* 2½*d.* in the former, and 25*s.* 6*d.* in the latter class. The author considers, however, that the manufacture is still susceptible of considerable development, both in the direction of improvement of produce and reduction of price.—R. A. SCHULTZ, *Zeitschrift für Berg-, Hütten-, und Salinen-Wesen*, vol. xxiv. p. 234.—H. B.

LIME JUICE. Much attention has been directed to the preservation of lime juice, under all circumstances, since the failure to employ it on the sledging expedition of the latest Arctic Expedition.

Mr. ROBERT ELLIS, surgeon, writes to the *Times*, suggesting the addition of pure glycerine. He says, alluding to the lime juice usually served out to the men, 'May I ask whether you ever tasted this stuff? I mean the lime juice supplied to our Royal Navy. Not to put too fine a point on it—as said the worthy law stationer in "Bleak House"—did you ever happen to have to drink our favourite medical prescription for effervescing physic?—mixed, not with the delicious fragrance and cleansing sharpness of lemon juice just squeezed from the golden cells of the lemon, concerning which SYDNEY SMITH said to be 10 miles from it was evangelism and heathendom, but made up, by the British chemist, of citric, or worse, tartaric acid, water, and a drop of lemon essence (or even of true lemon juice), which has become mouldy and covered with a layer of fungoid growth—did any of your readers or yourself taste it? If so, it is easy for you to understand how the bluejackets hate it, and but for actual coercion would not touch it. It is no wonder to me that this is really so. And to swallow lime juice icy cold and of repulsive taste and smell! It is a downright shame and disgrace to present to the men such abominable stuff as this, and I can only admire the discipline—and the disciplined—which gets this stuff down the throats of the sailors, even with the assurance from the officers that it will do them good. There, let us say, lies the hated drug, now turned to stone by awful cold, and it has to be chopped up like paving-stones, and only half molten given to the men. I do not wonder that the men prefer, as Lord PALMERSTON the gout, the threat of scurvy to the abominations of the lime juice. Now, sir, for the remedy. It is this:—After separating the albuminous parts of the juice, by heat or in other ways, let the liquid be well filtered through a thick flannel bag, and run off into glass or earthenware bottles; then a few drops of freshly prepared oil of lemons will be judiciously added to it. Now for my grand secret. Sweeten it with the purest glycerine obtainable, and, after a slight second heating, put it into properly prepared vessels, rigidly excluded from the atmosphere. Here is my prescription for a compound pleasant to drink, free of fungoid growths, and, above all, capable of preserving its fluid condition down to a very low point indeed. If any feel disposed to doubt the fact last named, let him go the Chelsea Glaciarium, and he will there see glycerine holding substances in suspension and in the liquid state, and sending them flowing through pipes at a temperature far below our ice mixtures—and so telling us how in future to prevent our poor sailors being disgusted with their best friend—and by this means made fluid and remaining so. It is this persistent fluidity which I here suggest, and hope it may be valuable. It will be a true gratification to me to learn that this humble memorandum leads to success—not less to you, by whose kindness I am allowed to make it known. The Glaciarium, used as a skating rink, in Chelsea, is a most valuable and interesting illustration of the wonderfully resisting power of glycerine, and possibly of other sweet compounds, against the force of the frost. It carries through many tubes its 'cold,' and—colder than ice—freezes without freezing. Add a lump or two of loaf sugar and a soupçon of lemon oil, and then a good jorum of hot water and fluid lime juice and old rum—and here you have a dainty cup to set before the Queen and the Queen's gallant sailors.'

LINEN. (Vol. iii. p. 120.) The international war in America was the means of creating great fluctuations in the linen trade of the United Kingdom. And even after peace had been proclaimed there were many changes in the manufacture which, taking the intermediate period down to 1876, present very interesting features of national interest. It will be recollected that the remarkable years of 1862–63 brought with them the cotton famine—an era in Britain's history which will never be forgotten by those who witnessed the terrible effects of that day of desolation. Mills were put on half time, and ere the close of 1862 many of them had ceased altogether; the factories shared the same fate, and ultimately tens of thousands of operatives were reduced to something approaching semi-starvation. But while production of cotton goods was brought down to a mere moiety of the turn-out in 1860, demand increased enormously for those low lines of linen which then came into play as substitutes for calico. Prices rose rapidly, and all the power of the steam loom and all the energies of hand weavers could barely meet current requirements. Home markets absorbed immense lots of coarse fabrics, while for the foreign trade there was any degree of

activity in warehouses. In 1861 there were 110,124,998 yards of plain goods exported from this kingdom, and that aggregate gradually rose until the year of extra activity (1866), when 232,837,903 yards were sent away. A partial lull came over the trade in the following year, which continued for the two succeeding seasons, when better times again marked the history of the manufacture, and in 1872 the exports had grown up to 233,838,338 yards. Very dull days followed, and for 1874 the total extent of business done with foreign and colonial customers was 146,791,516 yards. In the meantime the growing taste for printed goods was giving great stimulus to that department of the linen manufacture. The exports of this variety of goods in 1861 only reached the total of 2,617,576 yards; in 1864 there was an aggregate of 15,995,708 sent away, and in 1876 the figures were 13,205,640 yards. It will be seen, therefore, that, dull and inactive as was the general trade during the past year, the exports of printed linens were 500 per cent. above those of 1861.

During the fifteen years that have gone by since 1861 there has been a very satisfactory improvement going on in the demand for linens throughout nearly all the British colonies. In course of that year the Canadian Dominion took from our merchants and manufacturers goods to the value of 103,906*l.*; in 1866 the exports to the same colony amounted to 282,263*l.*, and to 261,939*l.* in 1876. To the Australian Isles there was sent in 1861 linens valued at 171,873*l.*; in 1866 the amount had increased to 323,316*l.*, and in 1876 a further advance was made, the figures standing at 357,632*l.* The United States, the leading seat of sale for British and Irish linens, took goods valued at 730,334*l.* in 1861—that was the first year of the war; an immense increase was experienced in the succeeding year's trade, and this increase went on till 1866, when the value of goods to the Republic of the West had risen to 4,412,084*l.*; a gradual decline followed, and in 1876 the value of all the exports to the United States had gone down to 2,900,336*l.*: still this figure very far exceeded that of the exports to any half-dozen of the other customers of Britain.

The Spanish West Indies have been doing a progressive business in flaxen fabrics. There was a total export for 1861 valued at 302,692*l.*, in 1866 the amount was 643,061*l.*, and in 1874 the goods taken off were valued at 756,064*l.* Germany, from whence in early times came over the men who taught Irish bleachers the best lessons they had ever received in the art of finishing linens, took in 1861 goods valued at 466,952*l.*, again to the value of 524,271*l.* in 1866, and a total of 569,352*l.* in 1876. Our neighbours over the Straits imported from Britain linen valued at 184,588*l.* in 1861; in 1866 they imported 282,550*l.*, and last year (1876) they took a gross value of 421,665*l.*

We have thus alluded to the comparative turns of trade in the linen manufacture, and shall now give some details connected with the supply of raw material, as well in relation to home produce as to that imported from foreign lands. The greatest yield ever taken off the flax-fields of Ireland was that of 1864, when there were 64,506 tons produced, but since then the acreable turn-out decreased considerably, that of 1868 having been only an average of 19 stones to the statute acre, against 34 stones in 1864. Only 24,987 tons were produced in 1868, and in 1871 the crop fell below the lowest point reached for more than a century. The average yield in 1876 off an area of 132,878 acres would foot up to about 24,000 tons, or nearly 20,000 tons under the quantity required to supply her own spindles. Taking the latest returns available as data, it would appear that on January 1, 1877, there were 865,500 spindles in motion at the flax mills in Ireland, 291,735 spindles in Scotland, and 275,120 spindles in England. This machinery would require about 72,500 tons of flax if every spindle was kept in full work 'all the year round.'

The imports of foreign flax in 1876 amounted to 70,233 tons, against 88,714 tons for 1874; but England has become the great store-house for laying up imports, and from her stock of the raw materials, brought from different parts of the globe, many of the Continental states draw a large proportion of their supplies.

Irish farmers have made considerable progress in the mode of cultivating flax. The class of fibre grown in 1876, taken on the average, is much superior to that of any produced in the more recent years, but there is still a great lee-way to be made up in the scutching department. Our Continental neighbours are far before us in the finish of flax for the market. Hand-scutching in Ulster has made considerable progress, and at present (March 1877) the prices paid for that finish are much higher in proportion than the rates current for milled. There is a lack of the best machinery for the scutching process, but there is often too great eagerness to get through the work, and the result is considerable waste and mal-finish of fibre. In the preparation of flax for the spindles genius and skill have not been lagging behind.

Many slight but valuable improvements have been made in the hackling machines. COMBE, BARBOUR, and COMBE's brush and vertical doffer vertical sheet hackling machine is in much favour with the Ulster mill-owners. Differing very little from some

others in principle, yet by careful attention to details and marking where improvements could be made, its proprietors have succeeded in giving this machine a high place as a finisher of medium and fine flax. The palm for superiority has been disputed by S. Cotton and Company, whose machine, got up on something like the same principle, has a very large class of admirers. Again we have George Horner's Duplex Stripper Bar Machine, which many spinners consider as quite equal to any of its rivals in medium and coarse work.—H. M'C.

Linen Exports in 1875 and 1876.

	1875		1876	
	Quantities	Value	Quantities	Value
	Lb.	£	Lb.	£
Linen yarn . . .	27,887,681	1,655,684	22,256,168	1,460,005
Jute yarn . . .	15,942,618	225,896	16,711,655	227,061
	Yards		Yards	
Linen and jute manufactures	186,763,770	5,904,066	140,791,560	4,366,673
Checked, printed or dyed, and damasks and dispers .	13,742,124	470,295	13,205,640	450,207
Sailcloths and sails . .	4,067,278	245,312	3,117,790	187,110
	Lb.		Lb.	
Thread for sewing . .	2,757,686	353,570	2,633,073	348,831
Manufactures unenumerated	—	300,779	—	269,293
	Yards		Yards	
Jute manufactures . .	102,105,579	1,404,097	121,060,570	1,660,563

LIQUIDAMBAR STYRACIFLUA, Fr.; *Liquidambar Copal*, Eng. This tree, belonging to the order *Hamamelaceae*, sub-order *Balsamifera* (Gray), is found in the United States of America, particularly in the southern districts. To obtain the balsam the rough bark of the tree is slit, and the gum resin collected as it flows out. The balsam has at first a yellow colour, and is of a syrupy consistence. After a time the colour darkens, and a hardness is formed having an aromatic odour, and which is soluble in alcohol, ether, chloroform, and the fatty oils. This balsam has been subjected to chemical examination by Mr. W. L. Harrison, whose results may be consulted in the *Arch. Pharm.*, (3) vi.

From the results obtained it is evident that *Liquidambar Styraciflua* is very closely related to *Liquidambar Orientale*.

LITHOFRACTEUR. See Explosive Compounds.

LITHOBOLOS. As the name somewhat imperfectly signifies, a machine for 'pulverising, or granulating.' A stone crusher used in Australia.

LITMUS. (Vol. iii. p. 135.) Litmus is said always to contain indigo. It has been thought that this may be derived from the urine used in its manufacture; but it is more probably an adulteration. When litmus is exhausted with spirits of wine, a filtrate is obtained showing a red or green fluorescence; from this alcohol containing acetic acid extracts a scarlet red colour, changed by ammonia into purple, like orcein. In this way the pure colouring matter of litmus is obtained. It is exceedingly sensitive, and may be used instead of tincture of cochineal for titrating the carbonates of alkaline earths in water.—'Colouring Matter of Litmus,' V. Wartha, *Deut. Chem. Ges. Ber.*, ix.

Wartha ('Ueber den Lakmusfarbstoff,' V. Wartha, *Ber. Chem. Ges.*, Berlin, 9, 217) describes four organic bodies separated from litmus.

1. By boiling commercial litmus with alcohol of 90 per cent., filtering cold, and boiling the clear tincture, *indigo* is precipitated.

2. By evaporating the violet-red mother liquor, there is obtained a beautiful red or, from many varieties green, fluorescent substance, indifferent to acids.

3. By digesting the litmus residue after the above treatment with alcohol with distilled water for twenty-four hours, and evaporating to dryness, and then treating it with absolute alcohol and acetic acid, a scarlet-red body is dissolved, which resembles orceine, and becomes purple red, in place of blue, with ammonia.

4. The brown powder invisible in the acidified absolute alcohol consists of litmus colouring matter in a state of great purity, so pure that by means of it the carbonated alkaline earths contained in spring waters may be titrated with as great delicacy as by the use of cochineal tincture, which is far from being the case with crude litmus.

Mr. Howard W. Mitchell read a paper before the American Chemical Society on June 1, 1876—'A Preliminary Note on Litmus'—in which he confirms Wartha's experimental results, except that he does not obtain the indigo. In the paper published in the *American Chemist* some interesting additional facts are given.

LOGWOOD. Used in colouring wines, and its detection. See Wines.

LONG MOSS. The *Tillandsia Usneoides.* This plant hangs from the boughs of trees like a tuft of long grey hair. The plant is collected and steeped in water, in order to remove the outer cellular portion, and the fibrous portion is used instead of horse hair.

LUBRICATING OILS. See Oils for Lubricating, and Vaselin.

LUDLAMITE. A Cornish mineral, having a near relation to Vivianite. It is, in the term of the new chemistry, 'a basic ferrous phosphate.' According to Mr. Frederick Field, F.R.S., who named the mineral, it consists of—

Oxide of iron	52·76
Phosphoric acid	30·11
Water	16·98
	99·85

Its hardness is 3·4; specific gravity 3·12; colour clear green from pale to dark, transparent and brilliant; streak very pale green, approaching white; powder greyish white. Before the blowpipe on charcoal tinges the flame slightly green, and yields a semi-fused blackish residue.

LUXULYANITE. Boulders of this rock are found scattered over a limited area in the parish of Luxulyan, in Cornwall, and a magnificent block was used for the sarcophagus of the Duke of Wellington in St. Paul's Cathedral. This boulder was known when *in situ* as the Hunter's Stone. The rock itself has never been discovered *in situ*. The granite, or schoriaceous granite, consists of a matrix of velvet-black tourmaline (schorl), in which were embedded grains of whitish quartz, occasional small and rather irregular crystals of felspar, and larger and more regular crystals of the same mineral—orthoclase—1 to 2 inches long, pinkish red in colour, spotted with white, which included masses of black tourmaline. Examination by the microscope showed that the matrix was composed of a dense mass of minute acicular crystals of schorl, matted together like intergrowing tufts of grass, and interspersed with white quartz. Examined under transmitted light, the rock was found to consist of a matrix of colourless quartz, often corroded with acicular crystals of schorl (bluish variety), of irregular grains of brownish tourmaline, and of crystals of orthoclase felspar more or less decomposed. The quartz was generally clear and pellucid, and here and there contained minute endomorphs, which in some cases appeared minute belonites, probably schorl, but often were amorphous brownish grains, like fine dust. The schorl occurred in acicular crystals massed together in tufts. The crystals, when cut across the prism, are translucent indigo blue or dull greenish blue; when cut lengthwise, of a drab or pale brownish stone colour. The crystals are hexagonal prisms. By polarised light the longitudinal sections exhibited strong dichroism. The quartz in which these crystals are embedded was not only crystalline, but consisted of various granules. With transmitted light the brown tourmaline was seen to form grains of irregular outline, traversed by irregular cracks. The porphyritic crystals of felspar, when examined microscopically, are seen to be much decomposed.

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MADDER AND ARTIFICIAL ALIZARIN. (Vol. iii. p. 158.) At the meeting of the British Association at Bradford, Dr. W. J. Russell read a valuable paper on the history of this colouring matter. The article referred to in the third volume was from the pen of Mr. Schunck, and is one of the highest class contributions to the literature of this important dye. Nothing has, therefore, to be added to that portion of the paper. Dr. Russell, however, has placed the history of artificial alizarin so very clearly that, notwithstanding what has been said in the present volume under the head of Alizarin (p. 45), it is thought advisable to extract the latter part of that communication.

'To trace the history of alizarin from its source we must go back to 1785, when an apothecary of the name of Hofmann obtained the calcium salt of an acid called quinic acid from cinchona bark. This acid is now known to be of common occurrence in plants; it exists in the bilberry and in coffee, in holly, ivy, oak-, elm, and ash-leaves, and probably many other leaves. Liebig also prepared the calcium salt, and was the first to give a complete analysis of it; the formula he gave for it was $C^{15}H^{24}O^{12}$. Baup, on repeating Liebig's experiments, arrived at a somewhat different conclusion, and gave the formula $C^{15}H^{20}O^{10}$. In 1836, at Liebig's suggestion to determine which formula was correct, Alexander Woskresensky, from St. Petersburg, then a student at Giessen, undertook the further investigation of this subject, and established the

formula $C^{14}H^{24}O^{12}$, the one, in fact, now in use. In the course of this investigation, which he carried farther than merely settling the percentage composition of this acid, he describes what to us is of most interest, a new substance having peculiar and very marked properties. He says that when a salt of quinic acid is burnt at a gentle heat he gets aqueous vapour, the vapour of formic acid, and a deposit of golden needles, which are easily sublimed. Afterwards he describes how this same golden substance may be obtained from any salt of quinic acid by heating it with manganic dioxide and dilute sulphuric acid; it then distils over, condensing in golden-yellow needles on the sides of the receiver, and may be rendered pure by resublimation. The composition of this body he finds to be C^3H^2O, and names it quinoyl, a name strongly objected to by BERZELIUS, as conveying a wrong impression of the nature of the body; he proposed in place of it the name quinone, by which it is still known. Far as this body would seem to be removed from alizarin, yet it is the study of its properties which led to the artificial production of alizarin.

'Some years afterwards WÖHLER also examined the decomposition of quinic acid; he prepares again this quinone, and follows exactly the process described by WOSKRESENSKY. He states that, with regard to the properties of this remarkable body, he has nothing particular to add; however, he proposes a different formula for it, and discovers and describes other bodies allied to it—among these is hydroquinone, $C^6H^6O^2$. LAURENT afterwards shows that the formula proposed by WÖHLER is inconsistent with his and GERHARDT'S views, and by experiment confirms the former formula for this body. Although many other chemists devoted much attention to this substance, still its real constitution and relation to other compounds remained long unknown. Thus WÖHLER, LAURENT, HOFMANN, STÄDELER, and HESSE all had worked at it, and much experimental knowledge with regard to it had been acquired. One important point in its history was, first, the discovery of chloranil by ERDMANN in 1841, and then HOFMANN showing that by heating quinone with potassic chlorate and hydrochloric acid, chloranil could be obtained from it—that, in fact, chloranil was quinone in which all the hydrogen had been replaced by chlorine. Perhaps the most general impression among chemists was, that in constitution it was a kind of aldehyde; certainly its definite place among chemical compounds was not known. KEKULÉ suggests a rational formula for it; but it is to CARL GRAEBE that we owe our knowledge of its true constitution. In 1868 he published a remarkable and very able paper on the quinone group of compounds, and then first brought forward the view that quinone was a substitution-derivative of the hydrocarbon benzol (C^6H^6). On comparing the composition of these two bodies it is seen that the quinone contains two atoms of oxygen more and two atoms of hydrogen less than benzol; and GRAEBE, from the study of the decomposition of quinone and from the compounds it forms, suggested that the two atoms of oxygen form in themselves a group which is divalent, and thus replace the two atoms of hydrogen; this supposition he very forcibly advocates, and shows its simple and satisfactory application to all the then known reactions of this body. This suggestion really proved to be the key, not only to the explanation of the natural constitution of quinone and its derivatives, but to much important discovery besides.

'At this time quinone seemed to stand alone, no other similarly constituted body being known to exist; but what strikingly confirms the correctness of GRAEBE'S views, and indicates their great value, is that immediately he is able to apply his lately gained knowledge, and to show how really other analogous bodies, other quinones, in fact, already exist. He studied with great care this quinone series of compounds and the relation they bore to one another—the relation the hydrocarbon benzol bore to its oxidised derivative quinone, and its relation to the chlorine substitution-products derivable from it. At once this seems to have led GRAEBE to the conclusion that another such series already existed ready formed, and that its members were well known to chemists—that, in fact, naphthalin ($C^{10}H^8$) was the parent hydrocarbon, and that the chloroxynaphthalic chloride ($C^{10}H^4Cl^4O^2$) and the perchloroxynaphthalin chloride ($C^{10}Cl^6O^2$) were really chlorine substitution-compounds of the quinone of this series, corresponding to the bichloroquinone and to chloranil—that the chloroxynaphthalic acid, $C^{10}H^4Cl(HO)O^2$, and the perchloroxynaphthalic acid, $C^{10}Cl^5(HO)O^2$, all compounds previously discovered by LAURENT, were really bodies belonging to this series—and, farther, that the supposed isomer of alizarin discovered by MARTIUS and GRIESS was really related to this last compound, having the composition, $C^{10}H^5(HO)O^2$. Farther, he was able to confirm this by obtaining the quinone itself of this series, the body having the formula $C^{10}H^6(O^2)''$, containing also two atoms less of hydrogen and two atoms more of oxygen than the hydrocarbon naphthalin; and to this body he gave the characteristic name of naphthoquinone. The chlorine compounds just named are, then, chloronaphthoquinones or chloroxynaphthoquinones, and correspond to the former chloroquinones; and MARTIUS and GRIESS'S compound will be an oxynaphtho-

quinone; many other compounds of this series are also known. Another step confirmatory of this existence of a series of quinones was made by GRAEBE and BORGMANN: as the chloranil could be found by treating phenol with potassic chlorate and hydrochloric acid, and quinone derived from it, they showed that in the next higher series to the phenol series, viz., with cressole, the same reaction held good; and by treating it in the same way they obtained a di- and a trichlorotoluquinone, $C^7\left\{\begin{matrix}CH^3\\(O^2)''\\Cl^2\\H\end{matrix}\right.$, $C^7\left\{\begin{matrix}CH^3\\(O^2)''\\Cl^3\end{matrix}\right.$, which in physical properties very closely resembled the corresponding compounds in the lower series. Other compounds have also been prepared.

In the next step we have the application which connects these series of discoveries with alizarin. Following the clue of a certain analogy which they believed to exist between the chloranilic acid $\left(C^6Cl^2\begin{matrix}(O^2)''\\(HO)^2\end{matrix}\right)$ and the chloroxynaphthalic acid $\left(C^{10}H^4Cl\begin{matrix}(O^2)''\\HO\end{matrix}\right)$ which they had proved to be quinone compounds and alizarin, believing that a certain similarity of properties indicated a certain similarity of constitution, GRAEBE and LIEBERMANN were led to suppose that alizarin must also be a derivative from a quinone and have the formula $\left(C^{14}H^6\begin{matrix}(O)\\(HO)^2\end{matrix}\right)$. This theory they were able afterwards to prove. The first thing was to find the hydrocarbon from which the quinone might be derived. This was done by taking alizarin itself and heating it with a very large excess of zinc powder in a long tube, closed at one end. A product distilled over, and condensed in the cool part of the tube. On collecting it and purifying it by recrystallisation they found they had not a new substance, but a hydrocarbon discovered as long ago as 1832 by DUMAS and LAURENT, and obtained by them from tar. They had given it the formula $C^{15}H^{12}$; and as apparently it thus contained once-and-a-half as many atoms of carbon and hydrogen as naphthalin did, they named it paranaphthalin. Afterwards LAURENT changed its name to anthracene, by which it is still known. FRITZSCHE, in 1857, probably obtained the same body, but gave it the formula $C^{14}H^{10}$. ANDERSON also met with it in his researches, established its composition, and formed some derivatives from it. LIMPRICH, in 1866, showed it could be formed synthetically by heating benzol chloride (C^7H^7Cl) with water; and BERTHELOT has since proved that it is formed by the action of heat on many hydrocarbons. This first step was then complete and most satisfactory; from alizarin they had obtained its hydrocarbon, and this hydrocarbon was a body already known, and with such marked properties that it was easy to identify it. But would the next requirement be fulfilled? would it, like benzol and naphthalin, yield a quinone? The experiment had not to be tried; for when they found that anthracene was the hydrocarbon formed, they recognised in a body already known the quinone derivable from it. It had been prepared by LAURENT by the action of nitric acid on anthracene, and called by him anthracenuse; and the same substance was also discovered by ANDERSON, and called by him oxanthracene. The composition of this body was proved by ANDERSON and LAURENT to be $C^{14}H^8O^2$, and thus bears the same relation to its hydrocarbon anthracene that quinone and naphthaquinone do to their hydrocarbons. GRAEBE gave to it the systematic name of anthraquinone.

'We have then now three hydrocarbons—C^6H^6, $C^{10}H^8$, and $C^{14}H^{10}$—differing by C^4H^2, and all forming starting-points for these different quinone series. Anthraquinone, acted upon by chlorine, gave substitution-products such as might have been foretold. It is an exceedingly stable compound, not acted upon even by fusion with potassic hydrate. Bromine does not act upon it in the cold, but at 100° it forms a dibromanthraquinone. Other bromine compounds have also been formed.

'Now, if the analogies which have guided them so far still hold good, they would seem to have the means of forming alizarin artificially. Their theory is that it is dioxyanthraquinone $\left(C^{14}H^6\begin{matrix}(O^2)''\\(HO^2)\end{matrix}\right)$, and, if so, judging from what is known to take place with other quinone derivatives, should be formed from this dibromanthraquinone on boiling it with potash and soda, and then acidulating the solution. They try the experiment and describe how, contrary at first to their expectation, on boiling dibromanthraquinone with potash no change occurred; but afterwards, on using stronger potash and a higher temperature, they had the satisfaction of seeing the liquid little by little become of a violet colour. This shows the formation of alizarin. Afterwards, on acidifying this solution, the alizarin separated out in yellowish flocks. On volatilising it they get it in crystals like those obtained from madder; on oxidising it

with nitric acid they get phthalic acid, and on precipitating it with the ordinary mordants, or other metallic solutions, they get compounds exactly comparable to those from the natural product. Every trial confirms their success; so, by following purely theoretical considerations, they have been led to the discovery of the means of artificially forming this important organic colouring matter. A special interest must always attach itself to this discovery, for it is the first instance in which a natural organic colouring matter has been built up by artificial means. Now the chemist can compete with nature in its production. Although the first, it is a safe prediction that it will not long be the only one. Which colouring-matter will follow next it is impossible to say; but, sooner or later, that most interesting one, scientifically and practically, indigo, will have to yield to the scientific chemist the history of its production.

'Returning for a moment to the percentage composition of alizarin, now that we know its constitution, its formula is established; and on comparing it ($C^{14}H^8O^4$) with all the different formulæ which have been proposed, we see that the one advocated by SCHUNCK was most nearly correct—in fact, that it differs from it only by two atoms of hydrogen. It is not without interest to note that the next most important colouring-matter in madder, purpurin, which so pertinaciously follows alizarin, is in constitution very nearly allied to it, and is also an anthracene derivative.

'Scientifically, then, the artificial production of this natural product was complete; but the practical question, Can it be made in the laboratory cheaper than it can be obtained from the root? had yet to be dealt with. The raw material, the anthracene, a by-product in the manufacture of coal-gas, had as yet only been obtained as a chemical curiosity: it had no market value; its cost would depend on the labour of separating it from the tar and the amount obtainable. But with regard to the bromine necessary to form the bibromanthraquinone it was different; the use of such an expensive reagent would preclude the process becoming a manufacturing one. But could no cheaper reagent be used in place of the bromine, and thus crown this discovery by utilising it as a manufacturing process? It was our countryman, Mr. PERKIN, who first showed how this could be done, and has since proved the very practical and important nature of his discovery by carrying it out on the manufacturing scale. The nature of PERKIN's discovery was the forming, in place of a bibromanthraquinone, a disulphoanthraquinone; in a word, he used sulphuric acid in place of bromine, obtaining thus a sulpho-acid in place of a bromine substitution-compound. The properties of these sulpho acids, containing the monovalent group HSO^3, which is the equivalent to the atom of bromine, is that on being boiled with an alkali they are decomposed, and a corresponding alkaline salt formed. Thus the change from the anthraquinone to the alizarin was effected by boiling it with sulphuric acid. At a high temperature it dissolves, becoming a sulpho acid, $C^{14}H^6 \begin{cases} (O^2)'' \\ HSO^3 \\ HSO^3 \end{cases}$; and then the further changes follow, as they did with the bromine compound. The sulpho acid boiled with potash is decomposed, and a potash salt of alizarin and potassic sulphite are formed; acid then precipitates the alizarin as a bright yellow substance.

'While PERKIN was carrying on these researches in this country, CARO, GRAEBE, and LIEBERMANN were carrying on somewhat similar ones in Germany; and in both countries have the scientific experiments developed into manufacturing industries. My knowledge extends only to the English manufactory, and if any excuse be necessary for having asked your attention to-day to this long history of a single substance, I think I must plead the existence of that manufactory as my excuse, for it is not often that purely scientific research so rapidly culminates in great practical undertakings. Already has the artificial become a most formidable opponent to the natural product; and in this struggle, already begun, there can be no doubt which will come off victorious.

'In the manufactory is rigidly carried out the exact process I have already described to you. In tar there is about 1 per cent. of anthracene; this, in a crude impure state, is obtained from it by the tar-distiller and sent by him to the colour-works. Here it is purified by pressure by dissolving from it many of its impurities, and, lastly, by volatilising it. Then comes the conversion of it into the anthraquinone by oxidising agents, nitric or chromic acid being used, then the formation of the sulpho compound by heating it with sulphuric acid to a temperature of about 260° C. The excess of acid present is then neutralised by the addition of lime, and the insoluble calcic sulphate is filtered off. To the filtered liquid sodic carbonate is added, and thus the calcic salt of the sulpho acid is changed into the sodic salt, $C^{14}H^6 \begin{cases} (O^2)'' \\ NaSO^3 \\ NaSO^3 \end{cases}$. This is afterwards heated to about 180° C. with caustic soda, thus decomposing the sulpho acid and forming the soda salt of alizarin and the sodic sulphite. The alizarin salt

so formed remains in solution, giving to the liquid a beautiful violet colour. From this solution sulphuric acid precipitates the alizarin as an orange-yellow substance. It is allowed to settle in large tanks, and then is run in the form of a yellowish mud, which contains either 10 or 15 per cent. of dry alizarin, into barrels, and is in this form sent to the print-works, and used much in the same way as the original ground-madder was used.

'This alizarin mud, as I have called it, containing but 10 per cent. of dry alizarin, is equal in dyeing-power to about eight times its weight of the best madder, and is the pure substance required for the dyeing, in place of a complicated mixture containing certain constituents which have a positively injurious effect on the colours produced.

'The scientific knowledge and energy which Mr. PERKIN has brought to bear on the manufacture of this colouring-matter seem already to have worked wonders. The demand and supply for artificial alizarin are increasing at a most rapid rate, and yet the manufacture of it seems hardly to have commenced. The value of madder has much decreased; and, in fact, judging by what occurred in the year of revolution and commercial depression (1848), when the price of madder fell for a time to a point at which it was considered it would no longer remunerate the growers to produce it, that point has now been again reached, but certainly from very different reasons. Last year artificial alizarin equal in value to about one-fourth of the madder imported into England was manufactured in this country. This year the amount will be much larger.

'Thus is growing up a great industry which, far and wide, must exercise most important effects. Old and cumbrous processes must give way to better, cheaper, newer ones; and, lastly, thousands of acres of land in many different parts of the world will be relieved from the necessity of growing madder, and be ready to receive some new crop. In this sense may the theoretical chemist be said even to have increased the boundaries of the globe.'

The cultivation of madder has suffered very considerably in the last few years: this is chiefly due to the manufacture of the artificial alizarin. The following table is given in AUERBACH's book on ANTHRACEN:—

1860–1861	 26,000,000	kilos. of 2,204 lb. avoirdupois.
1861–1862	 27,000,000	" "
1862–1863	 27,400,000	" "
1863–1864	 26,000,000	" "
1864–1865	 24,000,000	" "
1865–1866	 26,500,000	" "
1866–1867	 18,000,000	" "
1867–1868	 19,500,000	" "
1868–1869	 17,750,000	" "
1869–1870	 16,000,000	" "
	228,150,000	" "

Yearly average, 22,815,000 kilos. Average price, 50 kilos = 41 francs.

MADDER, *&c., imported in the Years* 1875 *and* 1876.

Countries	1875		1876	
Madder.	Cwt.	£	Cwt.	£
From Holland	8,767	21,968	14,275	28,060
" France	28,231	66,651	10,567	22,707
" other Countries . .	1,243	1,759	728	1,306
Total . . .	38,241	90,387	25,570	52,073
Madder Root.				
From Holland	11,222	17,768	1,821	2,845
" France	—	—	3,663	9,029
" Italy	19,162	27,432	12,016	14,346
" Turkey	30,742	50,951	16,213	18,809
" other Countries . .	2,855	6,609	78	64
Total . . .	63,981	102,760	33,824	45,093

Countries	1877		1878	
	Cwt.	£	Cwt.	£
Madder Garancine.				
From Holland	9,867	89,220	8,198	94,027
„ France	15,031	126,900	7,174	47,291
„ other Countries . .	967	4,203	26	120
Total . . .	25,865	220,323	15,398	142,038
Madder Munjeet.				
From all Countries . . .	—	—	419	590

MADDER FLOWER. (*Fleur de Garance*). This colour is obtained from madder by fermentation. The madder is stirred up with twice its weight of water, which is then run off. The liquid is allowed to ferment, and contains most of the sugar present in the madder. The moist residue is again mixed with water, and the whole is allowed to ferment. The yield of madder flower is from 30 to 40 per cent. of the raw material. Its tinctorial power is estimated at double that of madder, and it yields a purer purple.—*Anthracen. By* Auerbach, *translated by* W. Crookes, F.R.S.

MAGENTA IN WINES. A writer in *Les Mondes*, September 29, 1876, states that magenta has come into use as an agent for adulterating wines on a scale which can scarcely be imagined.

A small commune in the neighbourhood of Béziers containing only 1,800 inhabitants has consumed in one year 30,000 francs worth of this dye for sophisticating wines. See Wines.

MAGNESIA CHLORINE PROCESS. (See Chlorine, &c., vol. i. 781.) This was a process introduced by Mr. Weldon, in which magnesia was substituted for lime.

'The process commences by neutralising the acid liquor from the stills, formed by the action of hydrochloric acid on native manganese, with Greek stone or very nearly pure magnesite (carbonate of magnesium).

'Or, if it be desirable, the Greek stone may be first calcined, and the light, easily-dissolved magnesia powder so made used in its stead. This operation is performed in a well of cast iron, or the liquor may be neutralised in the stills.

'The mixed chlorides of manganese and magnesium liquor, obtained as described, are pumped into the settlers, where any peroxide of iron, alumina, and gypsum is deposited. This gypsum is derived from the sulphuric acid contained in commercial hydrochloric acid. From the settlers the liquor is run into an iron pot or pan, where it is evaporated until it attains a state of concentration—registering a temperature of about 320° Fahr. At this stage the evolution of hydrochloric acid gas commences, from the decomposition of the magnesic chloride by water. By opening a screw plug (of metal) it is now run into a muffle furnace, consisting of two divisions, which communicate with each other by means of an iron door worked by a pulley from without.

'In one of these compartments the evaporation to dryness is completed, and is accompanied by the evolution of much hydrochloric acid, *plus* a little chlorine. The residue, which by stirring constantly, at this stage, is broken up into thin cakes, is then transferred by means of a rake into the second compartment, where it is heated with access of air.

'Here the heat requires careful regulation, for if the temperature rises too high fusion ensues, and thus the porosity of the mass is lost and oxidation impeded. The best heat is one designated "blood red," and if this be attained and kept up, the oxidation proceeds very regularly till the end. The tendency to fuse on the part of the mixture is due to the magnesic chloride, and therefore it is greater in the first place than afterwards, when it is partially decomposed, as magnesia exhibits no such disposition. In other words, the furnace may be brightly red hot in the first compartment because the temperature is greatly reduced by the evaporation which there takes place. As the mixture passes into the second compartment of the furnace, it consists of manganese chloride, together with magnesic chloride and magnesia, hence it is at this stage that the temperature must be carefully watched; but as the decomposition proceeds the magnesic chloride becomes less and less in quantity, and therefore the temperature may be allowed to increase to some extent with the decomposition.

At the same time that the magnesium chloride undergoes decomposition, so also does the manganic chloride, and there is thus obtained protoxide of manganese, which absorbs oxygen from the air which is admitted and becomes peroxide. This latter body appears to combine with the magnesia under these circumstances, and forms what Mr. WELDON has termed manganate of magnesium ($MgMnO^4$), which, when properly made, is a dense, black, finely-divided powder.'—*The Alkali Trade*, p. 207.

MAGNET. The manufacturers of magnets—making them by touching with permanent magnets—have often noticed a state of supersaturation of horseshoe magnets, so long as the armature was allowed to remain attached, but which is dissipated at the first pulling off of the armature. HAECKER says that the portative force in this state is double the permanent force; this agrees with some experiments made by V. S. M. VAN DER WILLIGEN. He states that to saturate horseshoe magnets he places them vertically with their poles upon the poles of a RUHMKORFF coil, the circuit of which he opens and closes three or four times successively. It then appears that the magnetism of the magnets has then attained its maximum even of *supersaturation*. The magnet is then carefully slid, without lifting it, towards the edges of the polar planes of the electro-magnet. Arrived at the margin, the armature, well cleaned, is placed before the magnet, slowly inclining the latter, while its poles still remain in contact with those of the electro-magnet. As soon as the armature has closed the magnet, this can be raised without the slightest effort. Its carrying force is stated to be then nearly one-third greater than the usual permanent portative force of the best magnets, especially those of M. VAN WETTEREN, who has been long celebrated for the superior power of his magnets.—*Comptes Rendus de l'Académie des Sciences*, November 27, 1876. *Philosophical Magazine*, January 1877.

MAGNET EMPLOYED FOR DRESSING ORES. Mr. FREDERICK J. KING mounts a system of magnets on the periphery of a wheel, which is revolved, and in revolving sweeps along the surface of the ores from which the iron is to be removed. We have been favoured with the following remarks from the inventor:—

'*Magnetic Process.*—1. Spathose iron ($FeO.Co^2$) (density 3·85), when mixed with blende (ZnS, density 4·0), cannot be separated by washing.

'I heat these ores to a dull red heat, by which the carbonic acid is expelled, and the iron becomes magnetic. It may then be completely removed by the magnetic machine.

'2. Iron pyrites (FeS^2) and copper pyrites are frequently associated with blende; their densities being nearly equal, they cannot be separated by washing.

'I heat these until by the expulsion of a portion of the sulphur the *pyrites* becomes *magnetic pyrites*; this is quickly effected at a dull red heat, and the pyrites thus made magnetic and separated, the blende becomes valuable, though unsaleable before.

'3. Most of the above iron ores are found mixed with oxide of tin, and these ores are now stamped and burnt to render the iron lighter, when it is washed away and *lost* to obtain clean tin ore.

'I burn these ores (but with more air than is now the practice in Cornwall), and all the iron compounds become highly magnetic, and are separated from the tin by the magnetic machine. The iron pyrites found with tin ores usually contain both copper and silver, which are both saved by the process. Two samples from mines near Redruth gave by assay 4·75 and 5·12 per cent. of copper, and 1 oz. 12 dwts. silver per ton of magnetic iron.'

MAGNETIC NEEDLE USED FOR DISCOVERING IRON ORES. M. THALEN has recently conceived the idea of employing the magnetic needle to find not only the existence, but also, in some measure, the strength, the general direction, and the depth below the surface, of masses of iron ore. The method deserves notice, not only because of its simplicity and its practical utility, but because of the remarkable assimilation to which it leads, between the action of the magnetic deposit, and that of a single magnet suitably directed.

M. THALEN measures the intensity of the magnetic action, or rather of its horizontal component, at a series of points as near, and at as regular intervals, as possible, over the supposed deposit. The measurement is made with a declination needle, and with the aid of a movable magnet. The observer can, at will, place this magnet in a fixed and invariable position with regard to the needle, or remove it. In each place of observation, one first brings the needle to zero, after having withdrawn the magnet; then, bringing the magnet near, the angle of deflection is read off. The measure of the intensity of terrestrial magnetism (comprising that of the iron deposit) can be easily deduced. A certain number of observations enable us to trace lines of equal intensity, called *isodynamic lines*. On study of these lines, they are found to be disposed in two series of closed curves, surrounding, more or less regularly, the two points which correspond to the greatest and the least deflection; between these two series of lines is placed a line not closed, which may be called the *neutral line*, and which corresponds to points where the magnetic influence of the mineral is *nil*.

The distinct conclusions at which M. THALEN has already arrived are as follows.— The line which joins the two points of maximum and minimum, or the magnetic meridian of the mine, gives the general direction of the layer of ore. The intersection of this line with the neutral line, indicates the point where it is preferable to commence operations. Lastly, the distance from this latter point to that of the magnetic meridian of the place for which the deflection is minimum gives half the distance from the centre of the mass of ore to the surface. These two latter results are only applicable if the depth of the ore under the surface is considerable.

It is natural to suppose that the ore owes its magnetic properties to the inductive influence of terrestrial magnetism; the mass of ore, then, must present the character of a magnet, directed parallel to the inclination needle, but having its austral pole below, and its boreal pole above. When the needle of the compass is situated on the north side of the mine, the influence of the ore counterbalances, in part, that of terrestrial magnetism, and the deflection produced by the magnet, which is brought into action, will be a maximum. On the south side, the two influences are added to one another, and the deflection of the needle is a minimum. Then the general direction of the mass of ore is that of the line which gives the two points of maximum and minimum.—*Journal de Physique.*

The application of the magnetic needle to this purpose is not so new as M. THALEN supposes it to be. At least thirty-five years since, Mr. ROBERT WERE FOX proposed to use his dipping needle and deflectors for determining the presence of iron ore beneath the surface, and also for measuring off the quantity of iron ore (approximately) in the deposit.

MAGNETITE. (Vol. iii. p. 180, and IRON, vol. ii. p. 919.) See LAVA. As long since as 1869, Dr. C. F. CHANDLER drew attention to a non-silicated, highly aluminous magnetite from Winchester County, New York. Dr. KIMBALL, in the *American Chemist*, gives the following analysis of this mineral:—

	I.	II.	III.	IV.
Magnetic oxide of iron	46·86			
Bisulphide of iron	2·63			
Oxide of manganese	0·65			
Alumina	39·36	41·28	45·29	20·95
Lime	0·47			
Magnesia	7·18			
Phosphoric acid	0·22			
Silicic acid	0·51	0·32	6·82	13·97
Titanic acid	2·41	3·90	1·90	4·15
Water	1·18			
Metallic iron	34·44	35·82	29·16	40·32
Sulphur	1·40			
Phosphorus	0·09			

I, II. Granular, massive, resinous; III. Banded variety, grey in general colour, and sparkling—from the presence of a micaceous mineral; IV. Quartzose variety, grey and sparkling, like No. III., but without a banded or gneissic structure.

These magnetites have been strongly recommended for use in iron works by Dr. KIMBALL. As a refractory material, rich in magnetic oxide of iron, and free from deleterious minerals, this ore would seem to commend itself for the lining or fettling of the puddling furnace. From its probable infusibility at puddling furnace heat and the slow action upon it of acid slag, there is strong reason to anticipate that it will 'stand' better than ordinary magnetites, titaniferous magnetites, or even ilmenite. Such must have been the use made of the ore shipped from this locality many years ago, some of which appears to have been tested for this purpose by the BETHLEHEM IRON COMPANY.

Dr. KIMBALL continues his remarks and recommendations in the following words.—

Open Hearths, Regenerative or Gas-furnaces (SIEMENS *and* SIEMENS-MARTIN *processes*).—One of the most important conditions in producing iron and steel by the open hearths or direct processes, is a lining capable of resisting the high degree of heat requisite for the precipitation of iron, and at the same time capable of resisting the chemical action, without at least imparting undesirable properties either to the metal or slags. Dr. SIEMENS has recently described his experiments in search of such a lining, and the difficulties he met with. Quartz bricks used in the construction of the furnace melt rapidly away under the action of the lime used in their composition, besides what, in the SIEMENS process, it is requisite to add to the ore for the formation of fusible slag. Silicious material is, furthermore, objectionable in the construction of these furnaces, as it prevents the formation of basic slags. Hence Dr. SIEMENS,

following out a suggestion of M. Le Chatelier, undertook to construct the roof and sides of the furnace of bricks composed of beauxite, from Beaux, in France, an aluminous iron ore (also used as an ore of aluminium) consisting essentially of hydrous alumina, together with variable proportions of hydrous and anhydrous sesquioxide of iron. These bricks, although found to be equal in heat-resisting power to silex bricks, failed to answer the purpose, 'owing to the great contraction of the mass when intensely heated, and non-cohesion with the same material introduced for the purpose of repair.' Subsequent experiments by Dr. Siemens to solidify beauxite powder, previously calcined, resulted in the successful use of 3 per cent. of argillaceous clay as a binding material, together with about 6 per cent. of plumbago powder, which serves to reduce to the metallic state the sesquioxide of iron contained in the beauxite, thus rendering the mass practically infusible. Waterglass, or silicate of soda, answered the purpose of a binding agent with the advantage of setting into a hard mass at a comparatively low temperature, although this mixture proved inferior in practice. A lining of beauxite brick of the former composition, and bound together with fluid cinder, which protects the inner surfaces from contact with the flame, resists the heat and fluid cinders to a remarkable degree, as demonstrated at Birmingham by Dr. Siemens, who has observed that when beauxite is exposed to such intense heat it is converted into emery. The calcined beauxite used for the above experiments was of the following composition: Alumina, 53·62; sesquioxide of iron, 42·26; silica, 4·12. In the raw state this mineral, according to Dr. Siemens, contains some 12 per cent. of water. Other analyses give a much larger percentage.

The above analysis shows the beauxite used for these experiments to have differed from its average composition as given by Dr. Siemens:—

	SiO^2	Al^2O^3	Fe^2O^3	H^2O	
Beauxite, raw . .	3·5	59·2	24·5	12·1	Average of 9 samples, 1st group
" calcined .	4·01	67·89	28·00	—	
" raw . .	1·75	39·5	45·5	12·57	Average of 8 samples, 2nd group
" calcined .	2·02	45·53	52·45	—	
Belfast ore, raw .	3·5	35·0	38·0	21·5	
" calcined .	4·45	44·58	48·40	—	
		31·26	37·74	18·06	Owners' circular.

Unless further experiments should show the adaptability of other grades of these ores than the variety used by Dr. Siemens, the apprehension of its scarcity will hardly prove groundless.

The emery ores, or aluminous magnetites, from Westchester County, Massachusetts, and North Carolina, have a composition similar to that of the beauxite brick after being in use, except that the oxide of iron is in the form of magnetic oxide, which likewise becomes rapidly reduced in the presence of carbonic oxide. The purer varieties have a remarkably small proportion of silica, and this is probably in combination with magnesia and a small proportion of alumina, the aggregate amount of which in the form of silicates can prove no more objectionable than the clay added by Dr Siemens to beauxite, which in fact contains more silica and apparently in a free state. The earthy ingredients in the non-silicious emery ore, if ground sufficiently, will probably answer the purpose of a binding agent without the addition of plastic clay. These emery ores, therefore, seem to commend themselves for the purposes above described, and, *à priori* at least, to afford grounds for the belief that they will prove superior to beauxite or other hydrous ores of iron and aluminium of average, if not indeed of the best, quality. The anhydrous nature of the former obviates the necessity for calcining.

MAIZE. (Fr. *Blé*; Ger. *Der Türkische Weizen.*) The quantity of starch in the dry kernels of maize varies between 50 and 65 per cent. Gorham found 77 per cent. in American maize. Tyrolese maize, which is used on a large scale for brewing purposes, is found by Hanamann to consist of—

Starch	72·55
Dextrin	3·04
Albumin	·38
Non-coagulable protein (soluble)	1·33
Fibrin	2·46
Insoluble protein	7·67
Fat	4·62
Legumin	5·27
Extractives	·84
Mineral substances	1·94
	100·00

Maize has been malted in America for a long period, and beer has been brewed from maize-malt, but such beer rapidly turns sour, and possesses no durability. HABICH recommends maize flour, and says that more than 90 per cent. of extract can be obtained.

New maize contains 28 to 30 per cent. of water, and maize dried in the air 12 to 15 per cent.—J. HANAMANN: FÜHLING'S *Landw. Zeitung*, 1875.

MAIZE CAKE. Consists of the starchy and glutinous refuse fibre obtained in the manufacture of Indian corn. It is used for feeding cattle.

MAIZE OIL. The colour of the fat of maize depends upon the different varieties and belongs to the drying oils. Analysis gave—

Carbon	76·34
Hydrogen	11·38
Oxygen	12·28

Maize oil consists of the glycerides of oleic and palmitic acids.

MALADA. Sometimes MILADIA, a variety of coarse soft sugar. The name is used in America to signify any dark sugar, and it is frequently in hard lumps, yellow, brown, and black.

MALT, substitutes for, in brewing. See BREWING.

MALTOSE. A simple body obtained by Mr. CORNELIUS O'SULLIVAN by the action of malt-extract on starch.—*Journal of the Chemical Society*, April 1876.

M. BONDONNEAU regards it as a mixture of dextrine with dextrose.—*Comptes Rendus*, lxxxi.

MANGALERA. See INDIA RUBBER.

MANGANESE ALLOYS. The only useful alloy with metals other than iron, is MANGANESE BRONZE, *which see*. The alloys of manganese and iron are treated under FERRO-MANGANESE and SPIEGELEISEN. See IRON and STEEL.

MANGANESE BRONZE. See BRONZE, MANGANESE.

MANGANESE. *Blowpipe reaction.* When a mineral substance is suspected to contain manganese, it is commonly tested by fusion with carbonate of soda. The manganate of soda enamel is generally greenish blue when quite cold. (CHAPMAN.) See CHROMIUM.

MANGANESE, FERRO. See FERRO-MANGANESE, p. 365.

Manufacture of, in Austria.—The importance to the growing steel industry of a supply of ferro-manganese or 'spiegeleisen' of a high grade induces Professor BLAKE to bring to the notice of the *American Institute of Mining Engineers* some details of the method by which a superior article is produced in the Austro-Hungarian Empire.

At Reschitza, Hungary, and probably at Laibach also (the *Krainische Industrie-Gesellschaft*), ferro-manganese is made in a blast-furnace, with charcoal as fuel and limestone as the flux. The ore is a ferruginous mixture, containing about 37 per cent. of sesquioxide of manganese. It is silicious, and somewhat resembles in its appearance the manganese ore from Red Island, in the Bay of San Francisco, California. It contains about 29 per cent. of silica and some alumina, shown by the subjoined analysis:—

Analysis of Ore used at Reschitza for Ferro-manganese.

Silica	28·513
Alumina	8·073
Protoxide of iron	0·367
Sesquioxide of iron	19·031
Sesquioxide of manganese	37·224
Lime	2·430
Magnesia	0·261
Water	3·691

This ore in the furnace requires a large amount of limestone to be added as flux. The larger the quantity of limestone, or, the more highly basic the charge is made, the larger is the percentage of manganese in the product. Thus, by using 15 per cent. of limestone, and 85 per cent. of ore, the product contains about 25 per cent. of manganese. Doubling the amount of limestone, about 5 per cent. is added to the product, giving, say, 30 per cent. of manganese; trebling the quantity of limestone, the metal contains 35 per cent. of manganese. To recapitulate results obtained, we have—

15 Limestone 85 Manganese ore	}	gives 25 per cent. manganese.
28·6 Limestone 71·4 Manganese ore	} .	. gives 29 per cent. manganese.
42 Limestone 57 Manganese ore	} .	. gives 35 per cent. manganese.

In a trial with the ore of which an analysis is given, 43 per cent. of limestone was added, so that the oxygen ratio of the bases to that of the acids was as 15·88 to 10·68 = 1·48 : 1, or nearly as 1·50 : 1. This is a highly basic charge, but upon this depends the success of the operation and the percentage of manganese attained.

The blast must also be under high pressure, and be very hot. In making the ferro-manganese at Reschitza, the pressure equalled from 90 to 100 mm. of quicksilver, and the heat was carried to 250° Celsius, equal to 482° Fahr., the highest point attainable with the heating apparatus in use there. With a hotter blast, and still more limestone, an alloy containing at least 50 per cent. of manganese could be produced.

The quantity of ore, fuel, and flux required to produce 50 kilograms (100 lb.) of ferro-manganese, and the cost of this product at Reschitza, were approximately—

	Florins
1,400 kilograms of ore	2·94
5 hectolitres of charcoal	2·00
600 kilograms of limestone	0·21
Labour, &c.	1·00
Total	6·15

This is about equivalent to three cents a pound, or say $60 per ton.

Possessing a great variety and considerable abundance of manganiferous ores in the United States, it may be expected, at no distant day, that the ironmasters will produce sufficient supply for their home demand. At present the inducement to enter upon the manufacture is somewhat lessened by the influx of German spiegel, at a constantly diminishing price. The imports, at present, must be from 20,000 to 30,000 tons per annum, mostly from Germany, and the price is about $35 gold per ton, for a quality guaranteed to contain 10 per cent. of manganese. It is entered as ordinary pig-iron.

The domestic production does not exceed, probably, 7,000 tons per annum, but it is increasing. The Secretary of the American Iron and Steel Association, in his report presented February, 1875, gives the total annual consumption of spiegeleisen, by the eight Bessemer establishments in the United States when fully employed, as not exceeding 25,000 gross tons.

The New Jersey Zinc Company has three furnaces, each 20 × 7 ft., with a combined annual capacity of 5,000 gross tons. This company produced 4,072 gross tons in 1872, 3,930 tons in 1873, and 4,070 tons in 1874, which is about the present product. This spiegel is made from the residuum left after the extraction of the zinc oxide of the Franklinite and the associated silicate of zinc—Willemite. It is a highly manganiferous mixture, and is favourable for the production of superior spiegel of a high percentage of manganese. Its composition is about as follows (two analyses):

Iron	82·250	83·23
Manganese	11·586	11·67
Phosphorus	0·106	0·19
Silicon	0·367	0·99
Carbon	4·632	4·02

The Woodstock Iron Company of Anniston, Calhoun County, Alabama, commenced making spiegel in December, 1875, and have run out about a thousand tons to this date (1877), varying in manganese from 8 to 20 per cent.

The ore used contains a little over 20 per cent. of metallic manganese, and no phosphorus. It is mixed with 'lump ore' containing 58·25 of iron, 8·56 of manganese, and 1·042 of phosphorus, but these percentages are variable. The nature of the product is shown by the subjoined four analyses:—

	Dec. 14	Jan. 6	Feb. 1	Feb. 3
Iron	85·11	85·08	80·37	73·86
Carbon	3·66	4·83	4·04	4·32
Silicon	0·95	0·88	0·38	0·93
Phosphorus	0·10	0·17	0·18	0·197
Manganese	10·18	8·14	14·13	20·69

—Professor W. P. Blake, Newhaven.—*Transactions of the American Institute of Mining Engineers.*

Manufacture of, in Georgia.—Mr. MILLARD P. WARD describing, at a meeting of the American Institute of Mining Engineers, some experiments made by himself on the alloys of iron and manganese in the blast furnace. The ores at hand and available for the purpose were brown hematites, containing but a very small percentage of manganese, and various manganese ores containing a small percentage of iron.

It is hardly necessary here to call attention to the statements regarding the production of iron-manganese alloys from such ores, which are given by all the well-recognised authorities on metallurgy. Suffice it to say, in a few words, that they hold that the operation is practically impossible, and that in the use of oxides of iron and manganese, mechanically intermixed in the same ore, much difficulty has been found in producing spiegeleisen. Spathic ores, containing manganese chemically combined, are alone recommended for the production of spiegel, and even then it is said that well-managed furnaces produce only about 75 to 80 per cent. of spiegel, the balance of the production being white laminated pig or grey iron.

The first experiment, which was made in July (1876), resulted in the production of grey iron, which contained 8 to 10 per cent. of manganese; but as this was not the product desired, and as there was no literature on the subject showing that such iron could be used in the BESSEMER process, this trial was regarded as a failure, and the furnace continued in blast, making grey iron till August, no manganese ores being used. The next experiment resulted in the production of white iron, containing 6 to 7 per cent. of manganese, but too much phosphorus (0·75 per cent.) to be available for BESSEMER purposes. Up to that time Mr. WARD supposed that phosphorus might be eliminated in the furnace in the presence of considerable amounts of manganese. One reason for his entertaining such a notion was the comparison of the analyses of the 'spiegeleisen' of the MUSEN COMPANY, and the ores from which it was made; the former by FRESENIUS and the other by PETERS. The spiegeleisen contained 0·059 per cent. of phosphorus and the ore 0·50 per cent. When it was found that no such elimination of phosphorus took place, but that, as usual in the smelting of iron ores, all the phosphorus contained in the charge made its appearance in the metal, ores from other banks containing less phosphorus were employed, and the result was the production of 'spiegel iron' containing about the same percentage of manganese as the last, and only 0·12 to 0·15 per cent. of phosphorus. For about two months the furnace was worked on nearly the same burden, and nothing but spiegeleisen of slightly varying composition was produced. At times the percentage of manganese in the charge was increased, and resulted in the production of a higher grade of spiegel for a few days, but at the end of that time the furnace would begin to work badly, and the old charge would be resumed. A number of trials all resulted in the same way, apparently proving the statement of KERL: 'By a considerable excess of manganese oxides in the charge, a white iron is produced containing less carbon, less hard, and more infusible, without any increase in the percentage of manganese.'

About October 1, Mr. WARD determined to make a new experiment with more manganese ore and a much lighter burden than any hitherto employed. This resulted in the production of an iron containing 18 to 20 per cent. of manganese.

From this time on, the proportion of iron ore employed was gradually diminished, and the manganese ore slightly increased; by which means, when the constituents to form a proper cinder were present in the charge, alloys containing as high as 60 per cent. and over have been produced. But the proportion of fuel employed to the metal produced was so large, that a hot blast was erected and put in operation, by the use of which, and the employment of a mixture of coke and charcoal in the place of charcoal, considerable economy resulted, and the production was increased.

The following is an analysis of ferro-manganese made at Diamond Furnace, Cartersville, Georgia, by Dr. O. WUTH:—

Manganese (metal)	55·22
Silicium	·031
Phosphorus	·471
Slag	26·58

MM. TROOST and HAUTEFEUILLE, from an investigation of the combinations of the various metalloids with iron and manganese, draw the following conclusions as to the part played by manganese in iron-making. The manganese employed in treating impure irons combines with the foreign matters, and it is these combinations, either dissolved or disseminated through the bath, which render its purification the more easy by communicating to the elements to be eliminated the oxidability suitable to the corresponding compounds of manganese. This is often the case, but the manganese also plays a simpler part and one more easy to determine. The addition of ferro-manganese, a compound which is always rich in carbon, restores to the metal the

carbon which it should contain, and reduces the oxide of iron, with disengagement of heat, both by its carbon and by its manganese. The oxide of manganese formed in and disseminated through the metal does not present the same inconvenience as the oxide of iron, for it passes almost immediately into the slag, taking with it other impurities. Thus, whether manganese exist in the metal before its purification, or whether it be added after a prolonged refining, the important part which it plays in the metallurgy of iron is due—(1) To the formation of compounds which are produced with a disengagement of heat greater than that due to the corresponding compounds of iron; and (2) to the easy scorification of these compounds, for they possess the property of oxidising while disengaging more heat than those which contain the same proportion of iron, especially when these compounds occur, as is often the case in metallurgy, in the presence of a considerable excess of metal.

MANGANESE, ITS EFFECTS IN BESSEMER METAL. It is a well-known fact to all Bessemer steel manufacturers using a blooming mill, that ingots show large cracks in the first few passes of the rolls, which, in the following ones, do not always roll up satisfactorily.

'This deficiency in the quality of the product is generally called "red-shortness," though, in the writer's opinion, most unjustly so. Different explanations of the said peculiarity are given by the leading authorities, each works selecting one element as a special scapegoat for the inferior quality of the ingot. The sulphur is generally first charged as being the principal cause of all mischief in this direction; then, after ascertaining that sulphur is not higher than the average, and sometimes lower in the very worst heats, silicon has to bear its share of abuse. How and why silicon should affect the working qualities of the metal, the writer could never precisely learn, but is convinced that the doctrine of its pernicious influence is an established one with many.

'In cases where silicon failed to explain everything, resort was taken to calcium, aluminum, and some other known or unknown elements, without settling the difficulty.

'Every steel manufacturer knows that steel, rolling very badly in blooming, may be hammered to perfection, and, therefore, the mechanical test cannot be consistently taken as a criterion for its rolling qualities. Real red-shortness, however, will show sooner or later in the material, no matter how worked. The conditions favourable to prevent this 'want of body' are apparently due to the right proportion of carbon, silicon, and phosphorus to manganese, other conditions being equal; and the necessity of keeping this proportion within the proper limits seems to increase with the increased size of ingots. From many analyses made, both of good and bad steel, Dr. Wendel came to the conclusion, that with steel having little phosphorus the coefficient $\frac{Mn}{C + \frac{1}{2}Si}$ was larger than 0·8; and, with such as worked doubtfully or badly, it was smaller than this fraction, meaning, by the symbols, the respective percentages of the elements, carbon, silicon, and manganese, as estimated by the analysis of the steel.

'This assumption may seem arbitrary, and the small quantity of manganese in the product may be considered only indicative that there was not sufficient manganese present for the complete deoxidation of the metal, but, on the contrary, Dr. Wendel claims that a certain surplus of manganese must be present as a constitutional element of metal intended for blooming.

'Hot heats, that are liable to be blown too short, come mostly in this category, and this led to the opinion that the highly silicious irons were more likely to produce this want of body, a defect which may be easily remedied by blowing sufficiently, that is, removing both silicon and carbon as much as possible before recarburisation.

'A theory about the beneficial influence of the manganese in preventing the want of body may not be necessary. But Dr. Wendel inclined to assume that manganese combines with carbon and silicon in certain proportions in lieu of iron, thereby changing the constitution of the metal, although such a statement may seem very heterodox in view of the preponderance of iron present.'

Some time ago Bessemer steel came under Dr. Wendel's observation, of which the analyses showed the following composition:—

	1	2	3
Carbon	0·28	0·29	0·30
Manganese	0·907	0·837	0·925
Phosphorus	0·524	0·498	0·513
Sulphur	0·088	0·086	0·084

The analyses of three heats are given as sufficient to represent the composition of others whose working qualities were the same. This metal showed less sulphur than the average then manufactured; the quantity of manganese was more than sufficient

to neutralise both carbon and silicon, and still the ingots crumbled up under the rolls, and most of them had to be taken from the tables in many pieces after a few passes. Both low and high heats were tried, but either way it was impossible to roll the ingots without disintegrating them. This steel showed only a very slight reaction, if any, in the vessel on recarburisation; and looked, when poured into the moulds, exactly like decarburised, or rather, unmanganised metal. The only explanation for this strange behaviour might be that the spiegel used on this occasion contained little or no manganese. That this was not the case both the analysis of the spiegeleisen containing about 11 per cent., and of the steel, subsequently showed.

Phosphorus by itself does not impart such peculiarities to iron as those described above, and the only way to escape from this dilemma was to take for granted a large affinity of phosphorus and manganese at the temperature of the molten metal, both combining to some kind of phosphide of manganese in the act of recarburisation; so that manganese, instead of combining with the oxygen of the bath, combines with the phosphorus present, partly or entirely, and so becomes rather paralysed in its proper sphere. The fact of the manganese percentage being unusually high rather strengthens this opinion, inasmuch as the manganese, by simply combining with phosphorus, will not show any decrease of quantity otherwise produced by the oxidation of this metal. An explanation like the one given may be contrary to the traditional notions concerning the affinity of elements, but it must be doubted whether the affinities have been much studied at temperatures and under conditions such as those we are concerned with at present. Is it not just as unlikely that gas-bubbles should be retained in a molten metal where such a high temperature ought to give them a high degree of tension?

In order to overcome the bad influence of phosphorus in the rolling of Bessemer ingots, Dr. Wendt suggests that the percentage of manganese in the steel should be four times as large as that of phosphorus, in addition to the quantity required for the neutralisation of carbon and silicon, according to the coefficient given above. The proportions given may need modification, but they certainly do not yield a larger percentage of manganese than required, if the manufacturer desires to be safe. This would not exclude the possibility that sometimes steel with smaller percentages of manganese may roll tolerably well.

Before attempting to utilise, for Bessemer works, irons with a higher percentage of phosphorus than has hitherto been allowed, it would be well to investigate whether the quantity of manganese necessary to insure the good rolling of the ingot does not impart too much brittleness to the product when cold; and, according to results obtained, the manganese must be kept to the required limits.

The statement of the Terre-Noire authorities, that one part of phosphorus imparts to the metal a hardness equal to two parts of carbon, seems to be questionable. According to this statement some iron rails would compare very favourably with those of steel in wear, and still they show more wear, excluding lamination.—Dr. August Wendt, Troy, N.Y., *Transactions of the American Institute of Mining Engineers.*

MANGANESE AND SILICON, *effects of, on the Properties of Steel.* An interesting series of experiments were made by the late Professor Mrazek, of Przibram, on the properties of different alloys of iron, with carbons, silicon, and manganese. The materials used in making the alloys experimented on were iron wire, as pure as possible, and containing about 0·17 per cent. of carbon, silicide of iron, silicide of manganese, metallic manganese, graphite, and pure grey cast-iron. Suitable mixtures of these, to produce the alloys required, were fused in Hessian crucibles under a flux of quartz and cryolite or quartz and fluorspar. The crucibles were allowed to cool in the furnace, and the composition of each button of alloy produced was determined by analysis.

The silicide of iron employed was made by fusing together 100 parts of iron wire, 62 of sodium, 242 of quartz, and 105 of fluorspar. Its composition was as follows:—

Carbon	traces only
Silicon	7·42
Iron	92·58

It was very magnetic, of a hardness between apatite and felspar, and brittle at ordinary temperatures; but at a red heat it was easily forgeable; and at a white heat it also forged well, without cracking at the angles, and it might be welded perfectly. Quenched in water from a red heat it hardened slightly, but without alteration in the appearance of the fracture.

Particulars of the analyses and properties of five alloys made by fusing this silicide of iron with different proportions of iron wire, and graphite or cast-iron, are given in a table at the end of the paper. Two of these, containing respectively 0·258 per cent.

of carbon with 0·543 of silicon, and 0·176 of carbon with 0·216 of silicon, were soft and tough when cold, forgeable both at a red and at a white heat, and easily welded, though they did not contain any manganese; while any increase in the proportion either of carbon or of silicon rendered the alloy unforgeable to a greater or a less degree. Professor MRAZEK concludes from this that the remarkable forgeability and weldability of the silicide of iron itself is dependent on its freedom from carbon.

Silicide of manganese was made by fusing together, in a similar way, a mixture of chloride of manganese, quartz, cryolite, and sodium. The alloy contained 87 per cent. of manganese and 13 of silicon. It was whitish-grey in colour, with metallic lustre, not magnetic, and brittle when both cold and hot. It was unaltered in the air, and resisted the attack of all the mineral acids except hydrofluoric acid.

Metallic manganese was obtained by fusing, at an intense heat, a mixture of oxide of manganese with oil and lampblack. It was iron-grey in colour, fine-grained, very brittle, and as hard as quartz. In the air, and even in a stoppered bottle, it oxidised rapidly to a brown powder containing scales of graphite. Its composition was—

Carbon	combined	0·49
	graphitic	1·00
Silicon		traces
Manganese		98·51
		100·00

On fusing 17 parts of iron wire with 1 part of this metallic manganese, under a layer of cryolite and in a lime crucible, a button of steel was obtained of the following composition:—

Carbon	0·384
Silicon	none
Manganese	1·380
Iron	98·236
	100·000

This was slightly malleable at ordinary temperatures, but cracked at the edges. At a red heat it forged like iron, and was remarkably soft and ductile; at a white heat it also forged well, and welded with the greatest facility. Tempered in water, from a bright red heat, it became brittle, and as hard as quartz. This result is most interesting, as the effect of manganese on steel, in quantity so much greater than that required to prevent red-shortness, does not appear to have been before published.

Twelve specimens of steel were made by fusing together silicide of manganese, or metallic manganese, with different proportions of iron wire and cast iron. These all forged at a red heat; but some of them, especially two containing respectively—

Carbon	0·28	Silicon	1·02	Manganese	0·004
Carbon	1·01	Silicon	0·16	Manganese	0·240

did not weld. The percentages of sulphur in the specimens, where stated, varied from 0·01 to 0·02. All of them, even one containing as little as 0·15 per cent. of carbon, with 0·38 of silicon and 0·30 of manganese, though soft and tough in their untempered condition, became hard and brittle when quenched in water from a red heat.

MRAZEK deduces from his experiments the following conclusions:—

(1.) As affecting the forgeability of steel at a red heat, silicon and carbon are detrimental, while the presence of manganese is advantageous.

(2.) Carbon affects the forgeability of steel more than silicon. This difference is especially marked in working the metal at a high heat.

(3.) The favourable effect of manganese is more sensible in forging at a white heat than at a red heat.

Professor MRAZEK's hypothesis is that the foreign matters in steel exist as definite compounds, Fe^4C, Fe^4Si or Fe^2Si, Fe^2S, Fe^4P, &c., dissolved in or diffused through an excess of iron; and that the greater the proportion the free iron bears to the sum of these compounds, the greater the forgeability and weldability of the metal.—M. F. GAUTIER, *Bulletin de la Société de l'Industrie Minérale*, 2nd ser., vol iv., p. 383.

MANGANESE, METALLIC. M. A. VALENCIENNES prepares this metal by reducing the pure dioxide with charcoal, in a crucible lined with magnesia.—*Comptes Rendus*, lxx.

HUGO TAMM describes his process of smelting manganese ores on a large scale. The following is from the *Chemical News*, xxvi., p. 111:—

'Two fluxes are required. No. 1, or white flux, is prepared by mixing together ground glass 63 parts, quicklime 18½ parts, fluorspar 18½ parts. It is a fusible flux, and is principally required for the preparation of No. 2, or green flux.

'The latter is made by smelting together flux No. 1, 34 parts; lampblack or soot, 5½ parts; manganese dioxide of good quality, 60½ parts. The slag obtained in this operation alone is required. It presents a fine green colour from the presence of manganates, and when once prepared may be used over and over again, provided the manganese ore reduced is of tolerably good quality. It requires from time to time the addition of a little flux to increase its fusibility.

Crucibles.—On account of the high temperature required for the reduction of manganese, some difficulty was experienced in obtaining a crucible which would withstand the action of the molten flux, but it was finally overcome by lining the crucible with a paste made by mixing 3 parts of plumbago and 1 part of loam or fire-clay with a small quantity of water. This lining, which should not under any circumstances exceed half an inch in thickness, effectually protects the crucible.

Smelting the Ore.—The following proportions are recommended:—

Manganese dioxide, of good quality . . .	1,000 parts
Lampblack or soot	91 „
Green flux (No. 2)	635 „
Oil in sufficient quantity to wet the mixture.	

The mixture is introduced into a crucible prepared as above directed, and a cover of thick wood placed over it. The wood is carbonised during the smelting, and forms a charcoal cover, which protects the mixture from oxidation. A clay cover is subsequently luted over the whole. The crucible is then placed in a wind-furnace and slowly heated as long as fumes escape. The fire is then urged, and the crucible maintained at a white heat for several hours, the time actually required depending upon the quantity operated upon.

When cold the contents of the crucible are turned out, and the button of metal is detached from the slag and preserved in a well-closed bottle.

Refining.—The cast manganese obtained by smelting an ore containing 79·5 per cent. of manganese peroxide was found to contain, manganese 96·9, iron 1·05 with traces of carbon, silicon, and other metals. It may be refined by re-melting it in a close crucible with one-eighth of its weight of manganese carbonate.

MANGANESE ORES. (Vol. iii. p. 200.)

Great Britain.—The largest quantity of the black oxide of manganese obtained in this country in the last two years was got from the Chillaton and Hogster mines, near Milton Abbot, in Devonshire. In 1875 those mines produced 2,754 tons, the value of which was 13,770*l.*; in 1876, 2,430 tons, valued at 8,200*l.* The total produce of the English manganese mines in each of these years was as follows:—

1875							1876						
Quantity			Value				Quantity			Value			
Tons	cwt.	qrs.	£	s.	d.		Tons	cwt.	qrs.	£	s.	d.
3,205	11	1	15,906	0	0		2,796	17	0	9,783	10	0

Our imports of manganese have been in the years 1875 and 1876 as follows—

Countries from which imported	1875		1876	
	Quantity	Value	Quantity	Value
	Tons	£	Tons	£
Holland	1,949	7,902	945	2,462
Portugal	5,744	31,328	4,068	21,729
Spain	6,592	35,223	1,376	5,371
Australia	—	—	1,881	9,960
Other parts	2,220	11,997	644	5,137
Total	16,505	86,450	8,914	44,659

In 1876, 8,974 tons were imported, of the value of 44,659*l.*, but the names of the countries from which it came are not yet obtainable.

Virginia.—The manganese ores of Virginia imbedded in the Potsdam sandstone are composed of—

Mn^2O^3	MnO	Fe^2O^3	Al^2O^3	CaO	MgO	SO^3	P^2O^5	SiO^2	H^2O
65·20	4·75	6·20	3·93	1·43	0·41	0·30	0·42	14·20	3·02 = 99·86.

J. E. Mills, *American Chemist.*

South Africa.—Valuable deposits of manganese exist in the vicinity of the Cape, about fifty or sixty miles inland, in the sandstone formation of which the Table Mountain is an outlier.

New South Wales.—The ores of manganese have not been found in any great abundance in New South Wales.

Wad has been met with. At Long Gully, near Bungonia, it is met with, having a more or less botryoidal form and platy structure; of a black colour, soft, with a black shining streak; in association with quartz, both as small veins running through the quartz, and as an external coating or incrustation. A specimen from this locality was found to contain 1·57 per cent. of cobalt and 0·36 per cent. of nickel.—Dr. Thomson.

It is abundant in the diamond drift near Mudgee, both as a cement and incrustation; often dendritic in outline. The incrustation on many of the pebbles is evidently quite recent.

It is very common as dendritic markings on rocks in many parts of the Colony.

It is found to the north of Cotumla, loose on the ground; also at Orange.

A peculiar form of wad is found in cavities in the basalt at Hill End. This variety is very soft and porous, being composed of minute scales arranged loosely together in a concentric manner—in fact, having a structure similar to that of wood. Externally it has somewhat a frothy appearance, with a metallic lustre; so soft that it blackens the fingers, and will hardly bear handling without crushing.

Mr. M. M. Pattison Muir, F.R.S.E., communicated to the Manchester Literary and Philosophical Society on November 28, 1876, the fact of a large deposit of manganese having been found near Bathurst, New South Wales. The ore is said to constitute the greater part of a considerable mountain in that neighbourhood. Analysis gave—

Manganese dioxide	78·72	per cent.
„ protoxide	3·60	„
Oxides of iron and alumina	6·50	„
Silica	5·80	„
Moisture	4·75	„

If the percentage amount of the dioxide of manganese be calculated from the dried specimen, it will amount to 82·21.

Carniola.—The manganese ore of Vigunsca, belonging to the Carinthian Industrial Company of Laibach, occurs in the form of an irregularly stratified mass, varying in thickness from 3 to 12 ft., on the southern slope of the mountain of the same name, in the district of Radmannsdorf, Upper Carniola, about 25 miles northwest of Laibach. The bed of ore is interstratified in the schists of the Upper Trias (Werfener Series), and overlaid by the Hallstatt limestone, a higher member of the same formation. The deposit is known for about 1¾ mile along the strike in an east to west direction, and dips with the hill at an angle of about 35°, forming, apparently, an inclined basin between the Triassic and the Alpine coal strata which occur lower down the hill. The character of the ore varies to some extent, the general appearance being that of a mass of decomposed yellow clay-slate, carrying irregular strings and patches of dark-coloured manganese ores. The best portions, which are usually found nearest the roof, have a rough irregular surface, and are of a dark steel-grey colour when freshly broken. Stalactitic strings and crystals of calcite, produced by infiltration of water, are the only foreign minerals found in association with the ore. The average composition of the ore in an air-dried condition is as follows:—

Peroxide of manganese	26·09	Metallic manganese	31·40
Sesquioxide „	21·56		
Silica	18·87		
Peroxide of iron	8·10		
Alumina	3·11		
Carbonate of lime	5·90		
Magnesia	0·50		
Alkalies	1·67		
Water	13·72		
	99·52		

The proportion of peroxide of manganese, and, consequently, of available oxygen, is too small to allow of the ore being used for the production of chlorine; it is therefore utilised for the production of highly manganiferous pig iron by smelting it in admixture with spathic iron ores. The richest spiegeleisen, or ferro-manganese, in the Vienna Exhibition, containing 36 per cent. of manganese, was made from this ore in the Company's blast furnace at Sava and Jauerburg. Latterly ferro-manganese

containing 50 per cent. of manganese has been produced, which is principally exported to France, Belgium, and England.

The production of manganese ore was, in—

1873	2,375 tons
1874	2,950 „
1875	3,800 „

The cost of transport of the ore from the mine to the works at Sava has been reduced by this method from 7s. 6d. and 9s. per ton to 4s., of which amount about one-third represents the cost due to the Inclines. The wear of the rope, although doing double duty (i.e. the buckets travel over it in both directions), is very small, being barely perceptible after carrying a net load of 5,000 tons. The cost of the whole line was only about 800*l*., although it was constructed in the winter, in a perfectly barren country, more than 4,000 ft. above the sea-level, conditions involving considerable labour and trouble in the conveyance of the necessary material.—H. Fassel, *Zeitschrift des Berg- und Hüttenmännischen Vereines für Kärnthen*, vol. vii. p. 355.

Hesse, Grand-Duchy.—The quantity of manganese produced was as follows in the years named:—

	Tons	£	Price per Ton
1873	3,271	9,810	3 0 0
1872	4,422	13,265	3 0 0

(Country unknown). Dr. T. L. Phipson gives the following analysis of a sample of peroxide of manganese, largely used both for laboratory purposes and in the ash:—

Water	2·02
Peroxide of manganese	72·17
Manganic oxide	6·20
Ferric oxide	3·66
Alumina	0·90
Yttria	0·10
Baryta	0·58
Lime	4·01
Magnesia	0·24
Oxide of lead	0·14
„ bismuth	trace
„ copper	0·09
„ nickel	0·04
„ cobalt	trace
„ thallium	0·01
„ indium	distinct trace
Arsenic acid	0·15
Phosphoric acid	0·35
Carbonic acid	3·20
Potassa	0·70
Lithia	trace
Silica and rock	4·00
Loss including fluorine	1·44
	100·00

Chemical News, June 1876, which describes the steps of the analysis in detail.

MANGANESE VOLTAIC BATTERY. (See for Leclanché's Cell, 'Electric Light,' p. 350.) Recently Messrs. Muirhead, Worden, and Latimer Clark have patented a new manganese battery. To obviate several defects supposed to exist in manganese batteries, the inventors employ, instead of the porous earthenware a cell or diaphragm of vitreous earthenware, perforated with holes, and preferably of cylindrical form. Outside of this cell they place a carbon or platinum plate, surrounded by graphite and manganese (pyrolusite), each in small pieces or lumps, and intermixed—the whole being contained in an outer cell of glass, stoneware or other suitable material. Inside the perforated cell is placed a zinc pole, cast in the form of a hollow cylinder with a slit or slits up the side; or the zinc may be in the form of a solid rod or bar. The exciting reagent preferred is chloride of ammonium in a saturated solution. The carbon or platinum negative electrode is platinised, and sometimes also the graphite lumps surrounding the negative electrode. The two poles of the battery are provided with suitable terminals or connections. By the use of the perforated non-porous diaphragm, the action of the battery is not impeded by the formation of the oxysalts of zinc, and the cell is not liable to the bursting and disintegrating that takes place in the existing forms of batteries where a porous material is used.

When the carbon lumps are platinised, platinum is preferred as the negative electrode. By placing the negative electrode, surrounded by the carbon and manganese lumps, outside the perforated cell, a greater depolarising mass is presented to the zinc, and at the same time the resistance of the negative electrode is diminished. The zinc being placed inside the cell, and being cast in cylindrical form, permits of its being brought close to the inner surface of the perforated cell (thus diminishing the resistance of the battery), and being hollow and slit at the side, a large quantity of solution can be held. There is advantage in the use of a perforated non-porous cell, even if the zinc plate be placed outside and the carbon inside, but the other arrangement is preferred.

MANQUATA. The native African name of a gum resin, which is regarded as a copal gum, and is called by the African natives of the Mossulo country, of which it is almost entirely the product, *Manquata* or *Maquata*. It is known to exist north in the vicinity of Manque Grande, but it is 'fetish' for the natives to dig for it, and consequently they will not bring it for trade, and even refuse to tell the exact place where it is found.

Until about 1858 it was a principal article of export from Ambriz. Mr. Monteiro, who has had numerous opportunities of examining this substance, says: 'I believe it to be a fossil gum resin. I have examined quantities of it to discover any trace of leaves, insects, or other remains that might prove it to have been of vegetable origin, but in vain. It is obtained from a part of Angola where white men are not permitted by the natives to penetrate, and I have consequently not been an actual observer of the locality in which it occurs, but by all accounts received from intelligent natives it is found below the surface of a highly ferruginous hard clay or soil, at a depth of a few inches to a couple of feet. It is very likely that if the ground were properly explored it would be found deeper, but, most probably, this is as deep as the natives care to dig for it, if they can obtain it elsewhere nearer the surface. It is said to be found in irregular masses, chiefly flat in shape, and from small knobs to pieces weighing several pounds. These are all carefully chopped into small, nearly uniform pieces, the object being to enable the natives to sell it by measure—the measures being little "quindas" or open baskets. The blacks of the gum country are so indolent that they will only dig for the gum during and after the last and heaviest rains, about March, April, and May, and these, and June and July, are the months when it almost all makes its appearance; and they will only allow a certain quantity to leave the country, for fear that its price on the coast may fall, hence only a few tons of this beautiful gum are now obtained. . . . It is said by the natives that no trees grow on or near the places where the gum copal is found, and that even grass grows very sparingly. The very small quantity of red earth and sand attached to the gum shows it to be so highly ferruginous that I should imagine such was really the case.'—*Angola and the River Congo*, 1875.

MANURE. (Vol. iii. p. 202, and Manure, Artificial, vol. iii. p. 210.) Under the head of Phosphates will be found nearly all that is now on these matters.

Our *Imports* of manures, these being bones of animals and fish for manures only, in 1875 and 1876, were as follows:—

Countries	1875		1876	
	Tons	Value	Tons	Value
From Russia	11,930	£83,579	10,779	£58,708
" Denmark . . .	2,003	13,455	1,705	10,755
" Germany . . .	5,057	34,448	2,706	16,856
" Holland . . .	3,956	25,930	3,063	22,550
" Belgium . . .	1,074	6,996	—	—
" France . . .	6,971	66,045	5,711	38,876
" Spain . . .	4,360	27,061	—	—
" Italy. . . .	3,827	24,498	4,963	31,190
" Turkey . . .	8,188	54,559	6,568	37,291
" Morocco . . .	1,744	11,532	—	—
" United States of America .	3,221	23,553	2,631	17,276
" Brazil . . .	5,823	35,496	4,140	24,629
" Uruguay . . .	15,544	93,193	9,311	55,005
" Argentine Republic . .	18,613	111,071	27,099	163,266
" Other countries . . .	2,886	18,340	5,853	36,347
Total . . .	97,217	630,656	85,129	524,769

Guano is still largely imported from tropical countries, and still maintains its value as a fertiliser, its remarkable power of stimulating vegetation depending on the ammoniacal salts and the free ammonia which this peculiar substance contains.

The imports in the years 1875 and 1876 were as follows:—

Countries	1875		1876	
	Tons	Value	Tons	Value
From the West Coast of Africa .	4,345	£55,545	2,323	£30,267
„ Islands of the Pacific .	6,163	37,141	5,857	35,190
„ Chili	—	—	1,810	23,530
„ Peru	86,042	1,065,570	156,864	1,966,065
„ Brazil	816	10,865	2,044	21,927
„ Bolivia	9,698	63,824	22,743	149,089
„ Uruguay	2,325	19,155	664	5,508
„ Australia (Victoria) . .	1,575	10.127	1,597	10,024
„ Other countries . .	3,490	28,209	5,389	54,141
Total . . .	114,454	1,293,436	199,291	2,295,744

Unenumerated.

Countries	1875		1876	
	Tons	Value	Tons	Value
From Germany	35,614	£70,330	35,100	£77,478
„ Belgium	1,666	12,002	2,641	15,441
„ France	38,921	82,041	36,129	66,115
„ Portugal	18,931	73,655	13,914	53,033
„ United States of America .	72,347	177,362	90,943	223,698
„ Hayti and St. Domingo .	4,477	15,446	5,725	22,199
„ Uruguay	1,351	9,592	—	—
„ British North America .	—	—	5,646	20,344
„ British West India Islands	5,900	26,355	6,468	28,368
„ other countries . . .	8,682	32,130	8,141	36,494
Total . . .	190,889	499,213	204,747	543,165

Coprolites and Phosphatic Nodules are produced in considerable quantities in Suffolk, in Hertfordshire, and Cambridgeshire, while smaller parcels are collected in some of the south-eastern districts, the total quantity produced in 1876 being, according to the *Mineral Statistics of the United Kingdom*, 258,150 tons, valued at 625,000*l.*

Phosphorite or Phosphate of Lime was found in small quantities in North Wales, 209 tons being produced from the Berwyn range in Montgomeryshire, and 20 tons from Pennant in Flintshire.

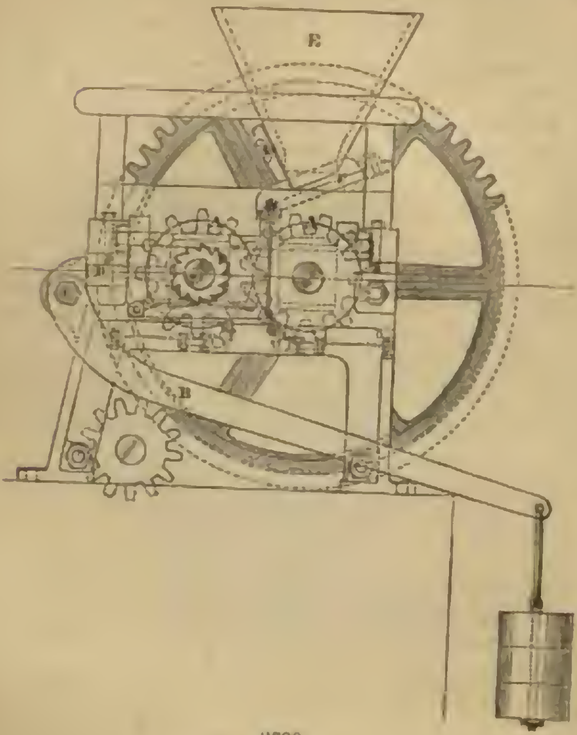
MANURE MILL MACHINERY. The basis of most of the artificial manures manufactured in this country are the phosphatic stones found generally in the Eastern Counties in nodulous forms. These, if large, are first broken by what is known as a 'BLAKE'S Stone Breaker' (see STONE BREAKER, and STONE AND ORE CRUSHERS, vol. iii. p. 916, and also in this volume).

Messrs. E. R. and F. TURNER, engineers, of Ipswich, have devoted a considerable amount of attention to the construction of mills for the preparation of artificial manures. From their machines the accompanying have been selected as showing, in the simplest form, the admirable construction of this class of mill. The drawings have been most obligingly furnished by the inventors.

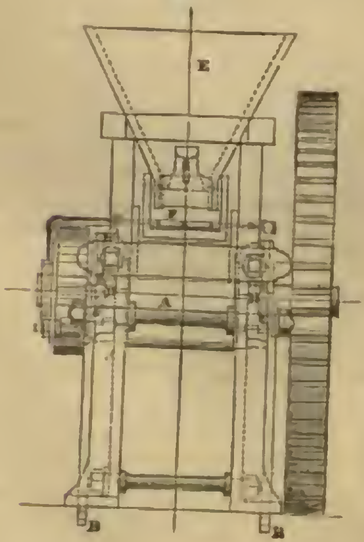
The material, after it has been broken in the stone breaker, is then passed through a crushing mill, shown in front and end views *figs.* 2397 and 2398, in which A A are the rollers; B B, powerful wrought-iron weighted levers with their fulcrums at C, giving pressure to the rollers through the pins, D D. E is the hopper from which the material falls upon a slide, F, which delivers it evenly to the rolls, in passing through which it is reduced to a suitable size for grinding. The latter operation is effected by the mill (*figs.* 2399 and 2400), the first representing it in elevation, the second in trans-

varse section. It consists of a very heavy pair of millstones, A being the runner, B the bed-stone. A is supported and balanced on the top of the spindle, C, which gives

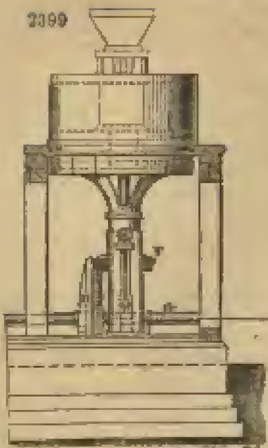
2397



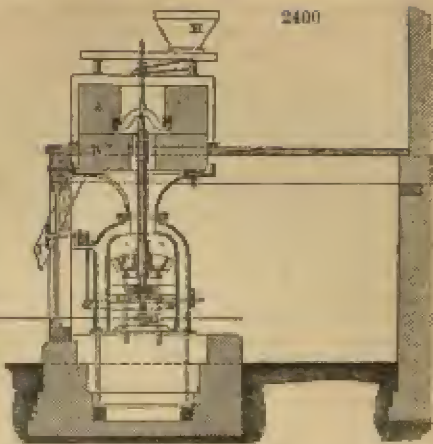
2398



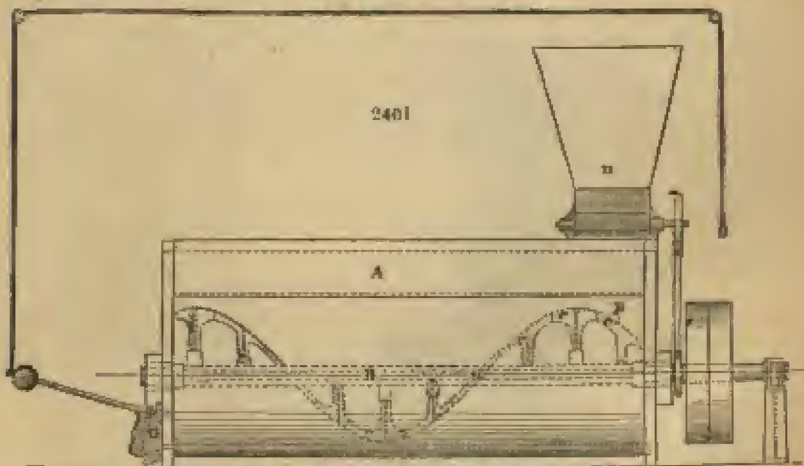
2399



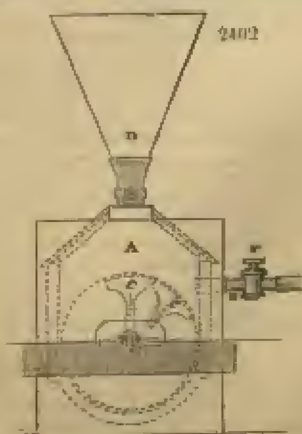
2400



2401



2402

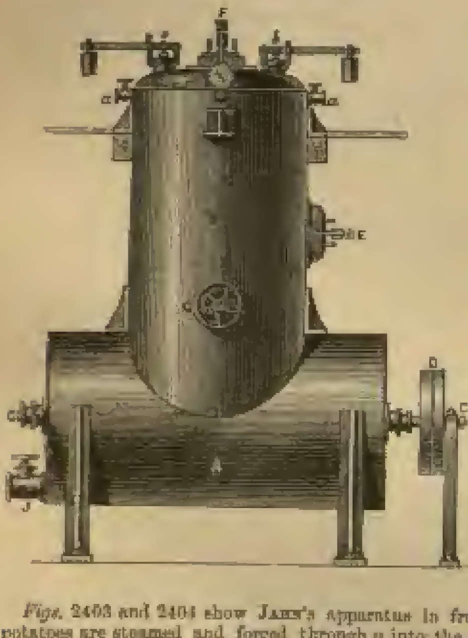


it rotation through the bevel wheels, D F, from the revolving shaft, G; the material is fed through the hopper, H, and passing down through the eyes of the runner stone, is ground between the face of it and of the bed-stone, and is delivered through the spout, I, in the state of an almost impalpable powder.

It is next carried, usually by mechanical means, to the mixer (*figs.* 2401 and 2402), which consists of a case, A, made of either wood or iron, lined with lead, having a horizontal shaft, B, running through it carrying a series of blades, C, C, C, fixed helically thereon. The ground material passes into the machine through the hopper, D, and simultaneously an almost equal weight of acid is admitted through the pipe, E, the supply being controlled by the attendant through the earthen cock, F. When the material is sufficiently amalgamated, the discharge is effected by opening the valve, G; the material, then in a fluid state, flowing out into the store below, where it quickly consolidates, and under the name of superphosphate possesses a high manurial value. See PHOSPHATES, &c.

MASHER. HERR JAHN, of Prague, has recently introduced a new system of preparing the mash for the distillation of potato spirit. For a long period a steamer manufactured by HENTZE has been long used in Austria, but JAHN'S appears to be a great improvement upon it. This masher is applicable to many other purposes; we therefore think it desirable to describe it.

2403



2404

Figs. 2403 and 2404 show JAHN'S apparatus in front and side views. In B the potatoes are steamed and forced through G into the disintegrator, A, which gives a mash of the finest and most even quality. When the mash has been cooled to the proper temperature the wort is introduced and worked up with the mash in the disintegrator. This is left till saccharification sets in, and is then run into the refrigerator through the cock, J. F is the manhole through which the potatoes can be introduced, E the manhole in the bottom of the steamer, *a* the steam-valve, *b* the safety-valve, *c* the manometer, H the cock for the condense-water, D the driving-pullies. The potatoes which are sent down into the disintegrator from the steamer offering so little resistance to their final reduction, the apparatus can very well be driven by hand.

This masher can be connected with the ordinary cylinders or steamers.

When a good mash tun is already in work, and the results are considered satisfactory, the upper part of JAHN'S apparatus can be used in combination with the mash tun. If desired, a refrigerator can be combined with it, and it can then be used

in the reduction of maize and corn. Maize, if used, should not be husked; and both maize and corn must be prepared for steaming by immersion for a suitable time in a steeping vat. The apparatus can be set up in a few hours.

MATAZIETTE, the name given to the explosive compound which destroyed the Fort de Joux, in Switzerland, in January last (1877), is simply nitro-glycerine mixed with sand and chalk and coloured with ochre. According to *La Nature*, its inventor, M. BREL, in April 1875 established near Satignix, in the canton of Geneva, a manufactory for it, which exploded, killing and wounding several persons. A few days afterwards six casks of matazictte were clandestinely despatched for Pontarlier and declared as manure; these were seized by the French custom-house officers of Verrières and sequestrated at the Fort de Joux. These six casks were next purchased by Swiss manufacturers.

The French railways being refused for transport of this dangerous merchandise, the purchasers sent cars to the fort to convey it away. This was attempted on the afternoon of January 18. Precautions of every kind had been taken to insure safety. Thus sheets of caoutchouc were spread on the ground, and the persons charged with manipulation of the casks wore woollen socks.

Spite of all precautions the mataziette, from some cause or other, exploded about half-past four. The effect was terrible. The new fort was entirely destroyed, a few sides of wall and a turret were all that remained. Enormous blocks of masonry, some of them a cubic mètre, were thrown on to the way between the old fort and the new, and broke the rails. The commotion from the explosion was so violent that a French custom-house officer, at a distance from the fort, was severely wounded by the fragments of glass from the window of a house near which he happened to be. The sound of the explosion was heard at a distance of several leagues, and the ground trembled considerably.

The place where the fort stood presents the aspect of a mere mass of *débris*.

M. HÉLÈNE, who was employed to examine into the cause of this explosion, attributes it to the defective manufacture of the BREL explosive. It may have been that the nitro-glycerine, as occurs where a defective absorbent has been employed, exuded, accumulating in a certain quantity at the bottom of the casks. The shock against the walls in loading may have caused the explosion of the liquid separated from its absorbent. Whatever the true cause may be, the disaster of the Fort de Joux shows once more with what care this explosive agent must be handled. See EXPLOSIVE COMPOUNDS, p. 355.

MEASURES, EGYPTIAN. The late Sir HENRY JAMES, R.E., F.R.S., has made the following remarks upon the ancient measures of length:—

'I have endeavoured to recover the correct lengths of the most ancient measures of length with which we are acquainted—viz., those of Ancient Egypt—not only because our own measures are obviously derived from them, but because we thus obtain the accurate relative value of the measures and distances given in the most ancient works on astronomy and geodesy which have come down to us.

'The ancient Egyptians employed two measures of length—viz., the common and the royal cubits.

'1. As regards the common cubit, we have the statement of HERODOTUS that the Egyptian cubit was equal to the Greek cubit, "that of Samos;" and we learn from the measurements of the Hecatompedon at Athens, by PENROSE, that the Greek foot was equal to 1·013 foot, or 12·156 inches, and, consequently, the Greek cubit was equal to 1·520 foot, or 18·240 inches.

'2. The most recent measures of the base of the first or Great Pyramid, that of King CHEOPS, viz., those made by the Royal Engineers and Mr. INGLIS, a civil engineer, give a mean length of 9·120 inches, or 500 cubits, of 18·240 inches, for the side of the square base, or 750 Egyptian feet, each Egyptian foot being equal to 1·013 English feet.

'3. The second pyramid, according to the measures of Colonel HOWARD VYSE and Mr. PERRING, has a base of 707·5 feet square, or 700 by 1·011 feet.

'4. The third pyramid has a base, according to VYSE and PERRING, of 354·5 feet, or 350 Egyptian feet square, of 1·013 English foot exactly.

'We may therefore assume that 1·013 feet was the true length both of the ancient Greek and the ancient common Egyptian foot, and that the length of the "common Egyptian cubit" was 18·240 inches.

'We have in the British Museum a double "royal cubit" found in the ruins of the temple of Karnak, in Egypt; and I found its length to be 41·40 inches, and that of the single cubit consequently 20·70 inches, or 1·725 foot.

'The pyramid which stands in the middle of the three, before the Great Pyramid (that of the daughter of King CHEOPS), has a base, according to VYSE and PERRING, of 172·5 feet square, and therefore 100 royal cubits exactly. But the same authors give the breadths of no less than seven of the passages in the pyramids, including the

entrances to the first, second, and third pyramids, all of 41·5 inches; being two cubits of 20·750 inches.

'DUVERNUE, from the measures of the nilometer at Elephantine, and of 3 or 4 cubits found in the ruins of Memphis, which almost exactly correspond with each other, estimated the length of the royal cubit at 20·721 inches (see CONDÉR, *Dictionnaire des Poids et Mesures*).

'Looking to these facts, and feeling it almost certain that the common and the royal cubit had some definite relation to each other, like that between the link and foot of our own country (66 feet equal 100 links), I infer that the most probable length of the royal cubit was 20·727 inches, and that 88 royal cubits were equal to 100 common cubits of 18·240 inches.

'This does not admit of rigid demonstration. But the dimensions of VYSE and PERRING seem to be given to the nearest half-inch only; and the measures of length sold in this country differ from one another quite as much as the length of the double cubit in the British Museum differs from its estimated length.'

MENYANTHIN. A bitter substance found in buckbean (*Menyanthes trifoliata*). It is obtained as a nearly colourless mass, which, after drying, is amorphous, friable, permanent in the air, neutral, and has an intense and purely bitter taste.—WATTS's *Dictionary of Chemistry*.

MERCURY. (Vol. iii. p. 227.) The following interesting notice of the production of cinnabar in California is from the pen of Señor DON F. SOLA:—

'At the time of the gold fever in California the gold-finders in the "placers" used to come across grains of reddish stone of so high a specific gravity that on washing the sands they always settled at the bottom of the cradles, after lighter matters had been removed. The name of "red stuff" was given to it by the miners, just as that of "blue stuff" was given to other numerous fragments of a bluish colour. The first were cinnabar, the second an extremely rich sulphate of silver.

'In a country where science and action come together for the common good, these indications were speedily utilised. When the importance of the "placers" became less, investigations of a costly nature were set on foot. At the cost of labours which would have discouraged less energetic and enduring men, the veins were discovered which are now great sources of wealth. At the present time New Almaden, New Idria, Napa, Colusa, Sonoma, and Lake Colorado afford ample field for the energies of the American race, which to its unresting exploration has added unceasing winning, and to these an unresting progress in the methods of treatment of the output. Three patents for distilling furnaces are in existence; RANDAL's, KNOX and OSBORN's, and LIVERMORE's. These are for treating poor ores, either in cakes or in a pulverulent condition. Ores differ very considerably in richness, the range being from 20 to 2 per cent. All has been the work of less than a quarter of a century, and at the present time more than half the world's consumption of quicksilver is yielded by that privileged country.

'The metal is brought to market in iron flasks holding 76 lb. (34·5 kilogrammes) of mercury. Of the total annual production of 100,000 bottles, 60,000 come from California. From the port of San Francisco, where the greater part of this is shipped, there have been forwarded, during the last fifteen years, 400,000 bottles, of the total value, in round numbers, of 2,850,000*l*. New Almaden, which for some years has been the most productive mercury mine in the world, produced 34,765 bottles in 1862, 40,391 in 1863, and 47,191 in 1864. The highest output in any year of the original (Spanish) Almaden mine was 32,336 bottles; its annual rate at present is restricted to 9,000 bottles. The results of the American production have been, in the first place, to arrest the upward tendency of the price of quicksilver, and, in the second, to increase the stock, as shown by the contrast between the 23,501 bottles entered at New York in 1874, and the 47,165 entered in 1875. In the third place, the consumption has so increased that China, which in 1872 took 1,000 bottles, figures in the statistical accounts of San Francisco in 1875 for 16,190 bottles; while Mexico, which in the first of these two years limited its demands to 3,761 bottles, took 5,757 in 1875. Lastly, the home consumption has been enabled to rise to 15,000 or 20,000 bottles a year, which is the quantity retained by the States for their own use. The Californian mines produced last year a total of 40,000 bottles, distributed as follows:—Redington, 13,000 bottles; New Almaden, 9,000; New Idria, 8,500; Guadalupe, 3,400; Great Western, 3,100; Saint John, 700; Liverdale, 700; Buckeye, 700; Manhattan, 450; Great Eastern, 400; Phœnix, 350. The weight here shown is about 1,420 tons. The production of Sulphur Bank, which takes the second rank among American quicksilver mines, and that of several mines of less account, were not included in the documents from which we extracted the foregoing figures.

'We can now see to what an extent the market has been modified. Spain has never been in a position to offer more than 40,000 bottles a year; the Almaden furnaces now producing up to a standard of 25,000 bottles, and the standard consumption

being about 100,000 bottles. The difference is furnished by other sources of supply than Spain. The quicksilver market, therefore, it is self-evident, is no longer a monopoly of Spain. It was ours so long as we were the only producers; but England, for whose custom all producers are desirous, as she consumes on her own account about half the total product, or say 45,000 bottles, has become the field of competition, and the market has been transferred to London. To this change the house of ROTHSCHILD has contributed by the share it has taken in quicksilver transactions, the possession of the Spanish mines having been made over to it for a certain number of years.

'Fortunately for ourselves (Spain), the heavy cost which the Californian mercury has to defray for carriage before it can make its appearance on the London market, as well as other charges which it has to bear before it leaves its port of exportation, affects it sufficiently to tell very decidedly in our favour, and make our competition possible. The time, however, is come when we should do well to rouse ourselves from any dream of undisturbed possession, and endeavour to get all the profit we can out of conditions which we are not in a position to annihilate. The decided tendency to rise, which was marked before the discovery of Californian cinnabar, has not only not been contra-indicated, but there has been a considerable decline.'

FRANCE.—In the detritus from the hill called 'Bois de Canilhac,' in the canton of Ganges, Département de l'Hérault, native mercury has been often noticed. It is also present in the detritus from a mountain forming part of the chain of Seranes, in the canton of Ste.-Martin de Londres (Hérault).—M. N. THOMAS, *Comptes Rendus*, lxxxii.

JAPAN.—Quicksilver is found in Japan, but it is not worked at present; there was one mine in Rikushin that was considered promising, but it requires a greater outlay to work it successfully than the Japanese seem inclined to invest; they appear to prefer lending their money out at the high interest usually obtainable, to expending their capital for an uncertain return. China imports nearly all the quicksilver used in Japan; in 1873 England imported 150 lb.

NEW SOUTH WALES.—The Rev. W. B. CLARK, M.A., says in the *Mines and Mineral Statistics*:—

'Some years since I reported on the occurrence of mercury in this colony, but my expectation of the discovery of a lode of cinnabar has been disappointed. The cinnabar occurs on the Cudgegong in drift lumps and pebbles, and is probably the result of springs, as in California. In New Zealand, and in the neighbourhood of the Clarke river, North Queensland, the same ore occurs in a similar way. About 1841 I received the first sample of quicksilver from the neighbourhood of the locality on Carwell Creek, on the Cudgegong, where the cinnabar is found. I proposed a full examination of that locality when I was in the neighbourhood in February 1875; but the state of the weather was such as to preclude the possibility of doing so during my limited stay. But I was informed that the progress of the mine was satisfactory.'

MERCURY ORES treated with bromine. See BROMINE; *its use in Hydro-Metallurgy*, p. 160.

Imports of Quicksilver in 1875 and 1876.

	1875		1876	
	Lb.	Value	Lb.	Value
From Germany	89,527	£13,013	48,045	£16,118
„ Portugal	2,731,725	589,141	2,356,753	[illegible]14,676
„ Italy	242,154	42,474	203,434	25,[illegible]9
„ Austrian Territories .	72,672	14,340	—	—
„ United States of America .	51,623	9,070	87,700	8,12[illegible]
„ other Countries . .	8,080	1,316	47,986	5,730
Total . . .	3,195,786	669,354	2,043,918	36[illegible],78[illegible]

See QUICKSILVER.

METHYL GREEN.—*Dyeing Wool.*—A process which has been found satisfactory consists in boiling the wool for fifteen minutes in a solution of hyposulphite of soda, 3 grams to 600 grams water; and when the wool is thoroughly penetrated with the liquid, adding two grams of sulphuric acid.

The dyeing is then performed in an aqueous solution of methyl green, great care being taken that the wool is perfectly clean, and that no metallic vessel be employed. If a yellowish colour is required, 0·07 grams of picric acid, and 0·06 grams of acetate of zinc are mixed with 600 grams of water. After dyeing the wool yellow in this *beck*, a little acetate of soda is added, and the dyeing is then completed with methyl green.—REIMANN'S *Färber Zeitung*, No. 47, 1875.

METHYL-DIPHENYLAMIN. See ANILINE, ELECTROLYSIS OF, p. 60.

METALS, ACTION OF DIFFERENT SOLUTIONS ON.—WAGNER has

made experiments on the effects produced by different solutions on various metals and their alloys :—

The COPPER employed was pure.

The ZINC, ordinary sheet metal, with 0·60 per cent. of lead.

The LEAD, ordinary sheet.

The TIN, pure-fused and hammered metal.

The BRITANNIA METAL, 90 per cent. of tin, 10 per cent. of antimony.

The BRASS, 64·5 per cent. of copper, 29·5 per cent. of zinc and nickel.

Strips of metal and alloys of equal sizes and thicknesses, were immersed in equal volumes of the solutions.

During one week air free from carbonic acid was passed through the solutions. In the second set of experiments, both air and carbonic acid were transmitted.

The solutions were of the following degrees of concentration :—In 100 c.c. of water were dissolved 0·5 grams chloride of potassium or sodium, 1 gram chloride of ammonium, 0·33 grams of chloride of magnesium, 1 gram sulphate of potash, 1 gram nitre, 1 gram carbonate of soda, 0·923 grams of soda.

Under I. are the amounts of diminution in weight of the strips of metal when air was transmitted; II. contains those when air and carbonic acid were transmitted; + indicates that the filtered solution contains some dissolved metal; (?) that only doubtful traces were found; 0, that none were dissolved.

Solutions		Copper	Zinc	Lead	Tin	Britannia Metal	Brass	New Silver	Iron
Distilled water	I.	? 1	? 14	? 3	0 —	0 —	0 —	0 —	0 20
	II.	+ 3	+ 19	+ 8	0 —	0 —	+ 4	+ 4	+ 54
Potassium and sodium chlorides	I.	0 4	0 7	0 21	0 6	0 9	0 2	0 1	0 42
	II.	+ 115	+ 38	+ 12	+ —	? 1	+ 30	+ 61	+ 72
Ammonium chloride	I.	+ 004	+ 61	+ 12	0 5	0 3	+ 269	+ 86	0 45
	II.	+ 138	+ 36	+ 5	0 —	0 —	+ 167	+ 116	+ 76
Magnesium chloride	I.	0 5	+ 18	? 20	0 1	0 1	+ 4	+ 3	? 40
	II.	+ 112	+ 54	+ 35	0 —	? 1	+ 92	+ 67	+ 65
Potassium sulphate	I.	0 —	0 30	0 —	0 2	0 1	0 —	0 —	0 —
	II.	+ 4	+ 53	0 —	0 —	0 —	+ 4	+ 4	—
Potassium nitrate	I.	0 —	0 9	0 14	0 3	0 1	0 —	0 —	—
	II.	+ 3	+ 37	+ 20	+ 1	+ 1	+ 8	+ 4	—
Sodium carbonate	I.	0 —	0 13	0 —	+ 7	+ 6	0 —	0 —	0 —
Sodium hydrate	I.	0 —	+ 60	+ 430	+ 220	+ 94	? 2	? 1	—
Lime water	I.	0 —	? 3	+ 137	0 —	0 —	? 2	0 —	0 —

The above numbers represent milligrams of the respective metals acted upon by the different solutions.

It will be observed that the effect of distilled water, free from carbonic acid, but in presence of air, is to produce a precipitate, but no appreciable solution of the lead. In presence of both air and carbonic acid, however, an appreciable amount of lead is dissolved, the solvent effect being increased three times by the carbonic acid. A solutions of alkaline chlorides in presence of air free from carbonic acid, produces a considerable precipitate, but no perceptible solution. With carbonic acid, however, though the action was only half as great, yet much lead was dissolved. A solution of sulphate of potassium had no effect. Lime water produces a reddish-yellow precipitate and considerable solution. The bearing of these experiments upon the use of those metals for cisterns for holding water and other fluids, will be obvious to all.—*Action of Different Solutions on Metals*, by A. WAGNER. DINGL. *Polyt. Jour.* ccxxi. p. 259.

METHYLALIZARIN dissolves in alkalis with a blue violet; with salts of lime and baryta, it forms blue precipitates. Methylalizarin dyes cotton mordanted with iron or alumina in shades closely resembling those produced by alizarin. KUNDT, in his spectroscopic examinations, was unable to find any essential difference between methylalizarin and common alizarin. It is therefore at present doubtful whether the methylalizarin did not contain an admixture of ordinary alizarin, which might easily occur during the fusion with potassa by abscission of the methyl group. —*Anthracen*, by AUERBACH, translated by CROOKES.

METHYLANTHRACEN. $C^{15}H^{12}$. This compound was obtained by WEILER and FISCHER on passing *dimethylphenylmethan* through ignited tubes filled with fragments of pumice stone.

Methylanthracen sublimes in beautiful large scales, which when white display a fine fluorescence.

METHYLANTHRAQUINON. $C^{15}H^{10}O^{2}$. This compound is obtained by the oxidation of methylanthracen in an alcoholic solution. If methylanthraquinon dissolved in sulphide of carbon is placed in a sealed tube with bromine and heated for some hours in a water bath, the result is a finely crystallised bromine compound, which, if fused with caustic potassa at 180° to 200° C., yields a dye resembling alizarin.

METHYLATED SPIRIT and **FUSEL OIL.** Whisky and other spirits may be examined for fusel oil or for *methylated spirits* in the following manner.—

Five ounces of the suspected spirit is distilled twice (about two-thirds each time), in an apparatus having the receiver connected, air-tight, with a condenser, which is furnished with a mercury valve, to prevent evaporation, being rendered alkaline the first time and acid the second time. The distillate is then shaken up with dry carbonate of potash, and again twice distilled, half-an-ounce being driven over each time. This contains the methyl alcohol.

This last distillate is diluted with water to a 10 per cent. strength, and the alcohol determined (1) by sp. gr.; (2) by GEISSLER'S vaporimeter; and (3) by oxidation. The difference between the amount indicated by oxidation and that shown by specific gravity gives a rough indication of the methyl alcohol present.

Should fusel oil be present, the spirit is oxidised by the dichromate of potash, the excess of dichromate then reduced by zinc, and the acids distilled off; the acid distillate is then neutralised by a standard solution of soda and then standard sulphuric acid, equal to one-twentieth of the soda employed, is added, the contents of the retort being then distilled at 150°. Acid is again added, and the liquid distilled to dryness. The acid distillate, containing the acids higher in the series than acetic acid, is neutralised by carbonate of barium and evaporated to dryness. From the barium present the amylic alcohol may be calculated.—A. DUPRÉ (*Pharm. J. Trans.*).

MÈTRE. See WEIGHTS AND MEASURES, vol. iii. p. 1119. At the page referred to will be found a woodcut of the mètre, of 39·371 English inches constructed in platinum. Recently Mr. MATTHEY, of the firm of JOHNSON and MATTHEY, sent in to the Academy of Sciences at Paris, a rule four mètres long, made of platinum and iridium, and executed for the International Geodesic Association. The metal was first tested in the laboratory of MM. H. STE.-CLAIRE DEVILLE and DEBRAY; then five ingots were cast, each of 450 ounces of platinum and 55 of iridium; each ingot was cut into small bits by the hydraulic press, and all these fragments were then melted together in the same furnace, and kept for a long time in a liquid state by an illuminating gas and an oxygen flame. The new ingot was forged on a polished steel anvil and hammer to match, and was thus transformed into a bar of the thickness of an inch, and breadth of nearly three, weighing 15 kilogramme in the air, and having a density of 21·52. One-third of the bar was cut off, and the rest forged and passed through cylinders and a steel draw-plate, until its dimensions were four mètres and

one-tenth in length by five and twenty-one millimètres in thickness and breadth respectively. M. Tresca, who is now engaged in the manufacture of the standard mètres for the foreign Governments who have adhered to the metrical system, objected to the rectangular section of Mr. Matthey's ruler, his mètres having a section shaped like an X, which would prevent their bending. He further made some remarks on the alloy, upon which M. Dumas, the perpetual secretary, rose and took Mr. Matthey's defence in the absence of that gentleman. He said he could not understand what were M. Tresca's grounds for attacking the new ruler, which had nothing in common with his international mètres; it had been executed with great precision and for another purpose, so that M. Tresca's strictures rested on no foundation.—*Les Mondes* and *Comptes Rendus*.

MICA. (Vol. iii. p. 240.) At Westfield, Massachusetts, mica has been discovered in considerable quantities on land owned by Dr. Packard, near the water-works reservoir, lying partly in Montgomery and partly in Westfield. The specimens exhibited were found in granite rock very near the surface, and have the tough, clear, silvery white appearance of the 'Muscovite mica,' which is valued so highly and used so largely. The specimens are hundreds of plates in thickness and large enough for stoves. Men are now prospecting (1876), who find evidence of large veins, and, in case their expectations are realised, a company will be formed to mine it. The Muscovite mica has only been found in this country in North Carolina and New Hampshire, but not in sufficient quantities to supply the demand, and large quantities are annually imported from the mines in Siberia. This discovery has, therefore, if all that is said of it be correct, an important value.—*American Mining Journal*.

MICROCLINE. A new species of triclinic felspar with a potash base. M. des Cloiseaux gives the following composition:—

Silica	64·30
Alumina	19·70
Oxide of iron	0·74
Potash	15·60
Soda	0·48
Loss on ignition	0·35
	101·17

Specific gravity, 2·54

MILLERITE. (Vol. iii. p. 413.) A sulphide of nickel: it is of a brass yellow colour and a metallic lustre, usually occurring in capillary crystals, commonly called capillary pyrites. It is found largely in the United States, in Lancaster, Pa. See Nickel.

MIMOSA SEED. A species of the mimosa, probably *M. marginata*, known in the Bahamas as the 'jumba bean' and the 'wild tamarind,' yields the seeds from which very pretty beads are made in the Bahamas, and imported as ornaments.

MINERAL COTTON. See Slag Wool.

MINERAL WATERS. See Waters, Mineral.

MINERAL OILS INDUSTRY. (Vol. iii. pp. 502, 544.) As stated in the previous volume, the mineral oils of the paraffin and petroleum series are still the sources of artificial illumination. The residual oils from the carbonisation of coal for gas pass into the hands of the coal-tar colour manufacturer as the source of his specialities. Alizarin, or a kind of it, is said to have been extracted from petroleum tar in France and America. Hitherto, British refiners have not been able to show the intimate affinity betwixt shale oil residues and ordinary gas coal-tar, by manufacturing from it similar tinctorial products to those yielded by the latter.

The mineral oil trade, as thus defined, during 1876–77 has been passing through a curious phase of its commercial history. At the commencement of the season, prices rose to such a pitch as to incite British mineral oil refiners with the hope that at length they had gained the coign of vantage in their hitherto protracted struggle with the product of the American oil wells. Were these sources running dry? And was the trade after all to assume the proportions anticipated ere the disastrous reverses in 1866 and the following years? So far as we now know, these anticipations were only partly true. A coalition of American refiners mainly caused the spurt of rising prices. Extreme caution should therefore be the normal condition of new entrants into this trade. The present produce of the Pennsylvanian oil region is said to be from 1,050,000 to 1,500,000 gallons in the twenty-four hours. From 1866 to 1870 inclusive, the average exportation amounted to 355,908 tons, but this rose to 705,200 tons during the next four years ending December 1874. Prices have oscillated in a corresponding ratio. Standard white petroleum, it was said, when first

brought to market, could not be sold under 1*s*. 8*d*. per gallon, so British manufacturers reckoned 1*s*. 6*d*. per gallon as the minimum price for their product. But they had to be contented with prices running from 1*s*. to 1*s*. 5*d*. in the years before 1872. Then till 1873 the price rose to 1*s*. 10*d*. per gallon; but in 1874 the price beginning at 1*s*. 1*d*. fell to 8½*d*., prices below 10*d*. per gallon ranging for six months in that year. But prices rose in 1876, above 2*s*. per gallon. Though decadence has marked the course of 1877, its autumn closes with the promise of a rise, as we would naturally expect if a ring of American oil operators dominate the market. The last of the small British manufacturers succumbed during the period of bad prices. Most of the Flintshire refineries, whose operations were referred to in former editions of *Ure*, are now broken up. Three or four large Scottish shale works, mostly joint-stock concerns, by dependence on profit from their heavy oils and paraffin, as well as an admirable utilising of their best waste residues, keep the burning-oil market low. Only about 5 per cent. of the American production reaches Britain, the major part being absorbed in the ever-increasing new markets throughout the world. Thus, in 1870, the exports of petroleum to the British East Indies were only 451,010 gallons, but this rose in 1875 to 3,926,590 gallons. Of course petroleum, or new material suitable for distilling for oil, may be discovered in foreign localities to affect this almost universal distribution of the American import. Experience seems to point to such materials being used only in the localities around which they are found. Large bituminous deposits have been recently found in Southern Italy, as well as a shale near Rouen, in France, said to yield 150 gallons per ton. But economic reasons demand that these be refined and manufactured on the spot. The extensive petroleum deposits of the Caspian Sea near Bakû, or those in the province of Yechigo, Japan, may yet tell on the Asiatic markets. At the latter place the petroleum is not refined owing to lack of chemicals, and is used in a semi-crude state. No commercial use has as yet been made of the discovery of smaller petroleum springs, either near Taranaki in New Zealand, or at Encounter Bay in the proximity of Adelaide, South Australia. Minerals like the Gallician ozokerite, which yield a large percentage of paraffin, may be profitably exported, specially should the paraffin so derived have, as in this case, a melting-point from 10° to 20° higher than that obtained from shale oil.

A few years ago it was propounded that the Pennsylvanian, Ohio, and New York petroleum regions were one system, through the length and breadth of which specially profitable oil belts ran. We now know this not to be the case. The recognised oil region of Pennsylvania forms a narrow triangle in the north-western extremity of that state, bounded, of course, on its eastern side by the Alleghany mountains. A possible petroleum territory of 13,000 square miles, of which 3,100 square miles have been tested by drill borings, which have again confined the richly oleaginous area to only 40 square miles, are the results of twelve years' experience. In the latter narrow space, upwards of 15,000 wells have been sunk. This is, of course, far beneath the anticipations of those who saw an oil-spring territory in the large space bordering and coincident with the American coal-measures on the geological map. Though oil pumping compares cheaply with distilling shale, the petroleum seeker has not always the clear margin thus implied. The operations of the derrick and drill usually 'strike oil' only once in every five attempts. The sinking of an efficient well is seldom done at a less cost than 1,000*l*. sterling; so the petroleum regions are no longer the places to seek sudden fortunes. Large companies now mostly conduct the operations. The high table-land which slopes from the watershed of the Alleghanies to the great lakes is undoubtedly an oil region. But prices do not warrant either its exploration or the necessary means of transport being laid down. So, too, in regard to California. Independently of what may be had on its higher regions, a petroleum spring has been observed a mile from its sea coast, and covering the ocean with its unmistakeable signs for two miles.

The first borers in the wooded gorges of the affluents of the Ohio 'struck oil' when they reached a layer of shingle and gravel roughly cemented together in a stratum of sandstone rock surrounded on either side by beds of shale. Beneath this, sandstone comes on, in which two successive shingle and gravel layers, yielding oil richly, were subsequently discovered. Only recently, another such bed lower down, and fully 1,000 feet from the surface, has been put on the well-borer's list. These shingle beds seem a necessity for the storage of petroleum, however it may be generated. And besides these four, a succession of similar beds may yet be found to prevail throughout the lower carboniferous measures of Pennsylvania, extending from 3,000 to 4,000 feet down. But though the sand rocks extend pretty uniformly over a large area, the shingle beds are very irregular; hence, one cause why oil-sinking is so uncertain. When the well sinker's drill pierces fine sand in the position of the shingle gravels in any of the sand rocks throughout the Pennsylvanian area, the quest for oil is known to be fruitless. Moreover, a richly-productive well may be, in petrolian

slang, 'wild catted,' or rendered barren of oil by other bores made too near it. But when deserted bore holes rest a while, they become again productive. Hence an oil well governmental conservancy has been advocated. When a sand rock is kept free of surface water, and not pierced by too many bore holes, the average life of a good well should be from ten to twelve years; few productive wells have, however, continued so for more than three years. The Pennsylvanian lower carboniferous strata do not uniformly preserve their great thickness. Near the great lakes, especially, the lower beds have been uptilted and afterwards denuded. And these differences in geognostic position exhibit distinctive petroleum products. The range of wells in the normal beds varies from 400 to 1,200 feet: gas wells being got at the greatest depths. They, too, are found in places where the denuded and uptilted strata are close to the surface. Where the middle strata occupy a surface area, the usual petroleum products are found; but the heavy machinery oils are mostly obtained from the upper sand rock.

Two main novelties in the economy of the petroleum manufacture are: (1) The system of pipe transport from the wells to the railway station, whence they are to be transhipped either to the refinery or the sea-board, and (2) The using of heavy petroleum oils for machinery purposes almost in their natural condition.

Tube lines of iron pipe, usually two inches in diameter, now carry petroleum from the well to the station, formerly one of the most serious items in the expense of winning the raw material. The tubes are made of Norway iron. Leakage is prevented by passing the tubes through an apparatus in which the hot tubes pass through a series of rollers in which the edges are first turned up, and then welded and pressed together. Tube lines, 20 miles in length, and capable of delivering 3,600 barrels of petroleum per day, are worked by four men. Two engineers relieve each other of the care of the pumping engine every twelve hours. At the transit station a man receives and gauges the oil as it flows out of the well; another, at the railway depôt, loads the oil into carriage tanks. The Pennsylvanian oil region alone has a network of 1,500 miles of such tube lines. The main pipes are three inches in diameter, but to these are joined many connections of two-inch pipe. If the cost and laying of the pipes were at 30 cents per foot, a capital of $2,682,000 has been thus expended. On one line, a three-inch pipe runs for a distance of 37 miles, with two relay stations. On the railways proper, enormous quantities of petroleum are carried in tank-waggons without any inconvenience or danger to the ordinary traffic. Tube lines have also been laid between the railway termini and the refineries.

American refiners prefer not to treat such natural heavy lubricative oils as that of Virginia by the ordinary refining processes of sulphuric acid and soda. They steam the crude product, afterwards distilling it in a vacuum still to separate the lighter oils from the real lubricant, which, so prepared, does not corrode journals or cylinders. After the oil is steamed, it may be filtered through animal charcoal. When thus prepared, it may stand a fire test of 400° to 500° Fahr.

Most of the heavy oil produced at the American refineries must be split up by successive distillations into the lighter products. About 245,775 tons are said to be produced yearly—a quantity much greater than that of all the animal and vegetable oils in the British market. It is simply inconceivable how such a total can be absorbed by the machinery of the United States. Dr. Chandler, the eminent New York analyst, finds that when this heavy oil is 'cracked up' it yields—

Crude naphtha	20 per cent.
Burning oil	66 „
Coke and loss	14 „
	100 „

Much of the crude naphtha must be used as fuel to aid these distillations, while some must pass into the bulk of the refined petroleum of the dangerous class, against the sale of which legislative enactment has been busy. The Americans have ample material in this enormous bye-product either for civic gas-making or in metallurgy. When either of these two uses, said to have been nearly practically realised, enter into the manufacturing phase, the burning-oil market will be seriously affected.

Refined American petroleum, as now introduced into the British market under specific trade names, has previously had all the dangerous light spirits removed by repeated fractional distillations. The following table, *inter alia*, shows burning oil of Scottish manufacture to be of much lower specific gravity than of yore:—

Comparative Yield of Pennsylvanian Crude Petroleum, sp. gr. ·782 to ·820, and Crude Paraffin Oil, sp. gr. ·810 to ·870.

	Per cent.	Sp. gr.		Per cent.	Sp. gr.
Gasolene	1½	·650	Naphtha	6	·740
Naphtha	10	·700			
Benzine	4	·730			
Refined burning oil	55	·800	. . .	45	·815
Heavy oil	17½	·875	. . .	10	·885
Paraffin wax	2	—	. . .	8	
Coke, gas, and loss	10	—	. . .	32	

Scottish refiners have, by a series of admirable economies, reduced the cost price of burning oil to betwixt 6*d.* and a fraction and 8*d.* per gallon. Less sulphuric acid is now used, insomuch that the largest company has had difficulty in consuming the products of their own chambers. Preference is given to the method of mixing the acid rapidly, and by injection, rather than that of the old mechanical iron stirrers.

The ether ice machines for cooling paraffin have displaced the revolving drums of Kirk, at Addiewell.

Mr. Young, of Clippens, has much modified and improved his self-heating retort, referred to in vol. iii. p. 507. Revolving horizontal retorts, said to yield six gallons additional per ton of shale, have been tried successfully; but difficulties of practical manipulation are said to have prevented their wide employment.

Young's Company now manufacture a lighthouse oil of 150° Fahr. flash-point, and only 815° sp. gr. It is largely used in France, America, and Britain. It is obtained by successive distillations, in the course of which the lighter oils are carefully removed.

This Company also advertise the 'Lavender' lamp, in which 'blue oil' is employed, and by whose flame, 12 inches long and 9 inches in circumference, such places as colliery or railway yards may be conveniently and economically lighted. The flame has a luminosity of 150 candles, and may be burned at a cost of 1½*d.* per hour. A steam jet must accompany the lamp: it both heats the fountain and creates a draught in the chimney.

Improvement in the ordinary household lamps have been so effected as to yield a light of 32 candles in a lamp with two wicks.

Gasolene is now obtained from the gas which used to flare up from the educt pipe of a bench of crude oil retorts. Mr. J. Coleman has extracted one gallon of this light liquid, hitherto associated only with petroleum refining, from 1,000 cubic feet of the gas; what gas remained over had heating power, but no luminosity. When the gas was pressed with 10 atmospheres, or 150 lbs. to the square inch, a liquid of 700 sp. gr. was obtained. But if beside this pressure a cold of zero, 32° Fahr., was applied to the gas, a volatile liquid of ·65 sp. gr. ran out of the educt pipe. An apparatus now successfully extracts gasolene at the Bathgate Works of Young's Company. It has been arranged in cognisance of the fact that gas, when allowed to expand, produces cold, especially if when in the act of expanding it performs such work as driving a piston. The following, in Mr. Coleman's words, are the details involved in the working of the machine:—

'1. The pumping of the gas by steam power into a system of tubes capable of being externally cooled, and from which condensed liquids can be drawn off by ball-cocks.

'2. Employing the compressed gas (after being deprived of its liquids) for working a second engine, coupled with, and parallel to the first, thus recovering a portion of the force originally employed in compression.

'3. Employing the expanded gas, after having had its temperature reduced in the act of doing the work of pumping, as the agent for supplying the necessary cold for cooling a portion of the condenser to 18° C., which is about zero Fahr.'

Gasolene is used in carburetting the air in the Illinois pneumatic gas apparatus; a gallon of the liquid thus producing 1,000 cubic feet of gas of 20½ candle-power. Country mansions, factories, and such institutions, out of reach of a public gas company, may thus have cheap illumination. The gasolene is placed in a tank in a yard outside the building, and sunk 6 feet below the surface, which is again, for greater safety, encased in another tank containing water. When the air is driven into the first vessel by an air-pump working automatically—the necessary pumping being regulated by a balance weight—sufficient gas is formed, without any annoyance from retorts, as in the rival means of supply. The insurance companies have accepted this invention in their rating. The danger of the gas flowing back into the air-pump is

skilfully obviated. As gasolene sells retail at about 1s. 6d. per gallon, consumers may obtain a cheap gas, and paraffin oil manufacturers a new source of profit. Mr. COLEMAN'S machine can operate on 250,000 cubic feet of gas per day, and as 3,000 cubic feet of gas are obtained from a ton of shale, so extra 3s. per ton are thus given to the manufacturer. Another patent proposes to collect the gasolene in coke, and then to wash it out.

The legal aspects of petroleum regarding flash-point and storage are by no means clear. The burning of the *Goliath* training-ship off Grays in December 1875 occurred through the upsetting of a petroleum lamp. As the oil appeared to have taken fire with extraordinary rapidity, it was assumed, in the first instance, that the flashing-point was below the parliamentary standard, but from the evidence given before the Coroner by the secretary of the PETROLEUM ASSOCIATION, the flashing-point was proved to have been abnormally high, being, in fact, 144° Fahr. 'In the case in question, the peculiar construction of the lamp undoubtedly contributed to the result, for the oil-reservoir was of metal, with no non-conductor interposed between it and the wick-holder, and the latter was fitted with a cone-shaped socket instead of being screwed, so that, when the lamp, which had been burning all night and had become hot, was dropped, the burning wick at once fell out, and ignited the heated oil which flowed over the oil-saturated floor.'

The Metropolitan Board of Works have exposed the dangerously permissive character of recent legislation regarding the legal flash-point of petroleum. Mineral oil, one or two degrees above the standard firing-point, may, if stored in a populous locality, cause sad disaster.

In a Berlin dye-work, where petroleum spirits are extensively used in cleaning the goods, they are stored in long iron cylinders, placed upright below the surface of the ground, and having their upper edges so curved as to expose only a limited surface to the atmosphere. In a recent fire only so much of the spirits as were exposed to the atmosphere in this upper curve burned; the bulk of the stored material escaped.

Superphosphate of lime, and alum-cake for precipitating sewage, have been added to the bye-products of mineral oil manufactories.

On the Production of Paraffin and Mineral Oil in Prussian Saxony.—The raw material of this branch of mineral industry, which is of comparatively recent origin, is a particular variety of earthy lignite occurring within a small portion of the Saxon Thuringian brown-coal formation between Weissenfels and Zeitz. This contains a fusible hydrocarbon, the so-called pyropissite of Kenrott, which, in the purest condition, yields by distillation as much as 66 per cent. of tar containing paraffin. The pure mineral is, however, only found in nests and patches in the lignite, the average of the coal worked giving 10 per cent. as a maximum of condensable products, but often less. Freshly raised coal containing a large proportion of water is found to yield better than that which has been dried by exposure to the air. Thus a series of comparative experiments showed that—

Coal containing 68 per cent. of water gave 40 lb. of tar and 16 lb. of gas per tub (of about 3 cwt.).

Coal containing 40 per cent. of water gave 33 lb. of tar and 44 lb. of gas per tub.

Compressed coal containing 26 per cent. of water gave 24 lb. of tar and 36 lb. of gas per tub; the increased quantity of permanent gases in the drier coals being obtained at the expense of the tar, a result which is to be attributed partly to the higher temperature prevailing during the distillation, and partly to the absence of the direct action of hydrogen in carbon owing to the want of water, which, as is well known, decomposes at a low heat by carbonaceous substances producing hydrocarbons and carbonic oxide.

The retorts used are of two kinds, horizontal and vertical. The former, which are used on the older works, are of cast iron, 8½ feet long, and of an elliptical section, 14 inches high and 28 inches broad. These are either set in pairs, each pair being fired separately, or in batteries of from twelve to twenty laid across the direction of the grate flame. The former method is generally preferred, as it allows the retorts to be more uniformly heated. The fire-grate extends along the bottom of one of the retorts, and passes through a side flue under the second, and returns over the tops of both. The fronts of the retorts are connected by goose necks of oval section, with a collecting main running along the front of the furnaces which conduct the volatile products to the condensers. This is made of vertical pipes like that ordinarily used in gas-works. A stop-valve is placed on the connection of each retort with the main to prevent the admission of air to the latter during the time of charging. The average amount of coal carbonised in the twenty-four hours is from 6 to 7 cwt., three charges being worked during that time. The coal is spread over the surface on a layer about 4 inches thick; the residual coke when sufficiently good is used in part for heating the retorts, but otherwise it is thrown away, or employed for road-making. The coal

required for heating the retorts is from 80 to 100 per cent. by volume of that distilled.

The yield of tar varies greatly with the temperature in the manipulation, the proportion of condensing surface being also of considerable importance. From 250 to 300 square feet is required for each retort, but a notable improvement in yield has been obtained by increasing it to 400 or 500 square feet.

The vertical form of retort which is adopted in all the newer works is a cast-iron tube 16 feet long, from 4 to 6 feet in diameter at the top, and somewhat less at the bottom, to which is adapted a conical discharging piece and a cylinder of about 2 cubic feet capacity, closed by two slide-valves for drawing the coke. The centre of the retort contains a system of thirty conical rings overlapping each other, Venetian blind fashion, built up round a central rod; the apertures between the rings form the passages for the volatile products, the coal being contained in the annular space between them and the cast-iron body, two large mouthpieces being provided to lead them to the condenser. The heating is effected by an external grate-fire, the retort being closely surrounded by an external casing of fire-bricks. The work goes on continuously, the charge of 82½ bushels of coal requiring about thirty-six hours for complete distillation. The coke is drawn at intervals of one to one hour and a quarter, each portion as it leaves the retort being allowed to cool between the slides of the coke-box before being discharged into the air. Latterly cylinders of fire-brick have been tried instead of cast iron, with fair results. The vertical form of retort, being continuous in action, does five times the work of a horizontal one; at the same time the process is more regularly conducted, and the yield of tar is larger. The average of five years' working showed the produce to be 70 per cent. of the theoretical yield of the coal with vertical, as against 66 per cent. with horizontal retorts.

The best results are obtained when the temperature is such that the gases leave the retorts at 302° to 392° Fahr.; above this point there is a greatly increased production of permanent gases, while below it the products are principally water and coke.

Another method, which has only been tried experimentally, is that of distilling in an atmosphere of superheated steam. This was found to give a higher yield both in regard to quantity and quality of the tar, but it has not been adopted in practice.

The product of the first operation is a dark-coloured (yellowish brown to black) mass of the consistency of butter, varying in specific gravity from 0·82 to 0·935, fusible at 59° to 86° to a brown fluid with dark green fluorescence. The best product is that of a medium density from 0·84 to 0·87, the average yield by rectification being 35 per cent. of benzine on various illuminating oils, 15 per cent. of gas on lubricating oils, 16 per cent. of paraffin, and 10 per cent. of creosote and pitch.

The rectification is conducted according to three different methods:—

1. Distillation of the tar, purification of the resulting crude paraffin by caustic soda and sulphuric acid, or by the latter alone, and redistillation of the purified product.

2. Treatment of the tar with sulphuric acid, washing with water and rectification with slaked lime.

3. Preliminary distillation with ½ per cent. of lime; treatment of the paraffin distillate with sulphuric acid.

The first of these is the oldest, and in many respects the safest, being adapted for all classes of material, but is attended with considerable loss of paraffin from decomposition during the distillation; the second is only adapted for the treatment of tar of low density; and the third is, in the author's opinion, the most advantageous, giving 16 per cent. of paraffin as against 12 or 15 per cent. by the other methods.

The operation is conducted in large stills containing from 35 to 50 cwt. of tar, the product being divided into two parts, known as crude oil and crude paraffin mass, the operation being made when the distillate solidifies when received upon a cold surface. The proportion is usually 40 per cent. of the former to 54 per cent. of the latter. The distillation is pushed to dryness, a residue of porous coke remaining in the still. Twelve hours are required to work off a charge of 40 cwt., after which the still is allowed to cool during the night, so as to be ready for filling early in the morning.

Treatment of the Crude Oil.—This is first cleared from creosote by mixing with caustic soda ley and settling; then treated with sulphuric acid to remove resin, ammonia, and other organic bases, next washed with water until completely freed from acid, and finally rectified by fractional distillation into various products, which are known by the following names:—

Benzine, specific gravity 0·790, boiling point 177° Fahr., used for removing grease spots from clothing, and also for carbonising coal-gas.

Photogene, specific gravity 0·800 to 0·805, boiling point 284° to 320° Fahr. This

is a mixture of several different hydrocarbons, and is used as an illuminating oil, and also for bleaching and removing the fat from bones in the manufacture of imitation ivory. When sold as German petroleum it requires to be 'petrolised,' that is, made to resemble American petroleum by a special treatment with sulphuric acid and strong soda ley, when it becomes perfectly clear, and shows a fine blue fluorescence.

The oils obtained from the crude paraffin are solar oils, specific gravity 0·825 to 0·845, and boiling between 350° and 400° Fahr. They are of a yellow colour, and form an illuminating material of very high class at an exceedingly low price.

Paraffin oils are those above 0·840 specific gravity, and boiling points between 500° to 518° Fahr. They are usually yellow and somewhat viscid, and are used for lubricating machinery. Notwithstanding the name, it is essential that these oils should be free from paraffin; and their lubricating value is improved by subjecting them to extreme cold in winter, in order to freeze out the last traces of that substance.

The crude paraffin, after the separation of the associated oils, is crystallised in blocks of 40 lb. weight, the crystals being separated from the liquid by hydraulic presses, centrifugal or other machines. The usual method is to effect a first separation in a chambered filter press, which gives a mass of crystalline scales, which are subsequently squeezed in a hydraulic press to cakes under a pressure of 200 atmospheres. The brown colouring-matter is removed by melting the crude press cake with 10 to 15 per cent. of benzine, and subjecting it to a second pressing. This is repeated with a further addition of benzine, and, after finally washing with water and a little sulphuric acid, the paraffin is set aside to crystallise. When so purified its melting point is 47° to 46° Fahr.

The composition of brown-coal paraffin differs from that made from the older coals and shales. The latter is nearly of the theoretical percentage composition, carbon 86, hydrogen 14, while the former contains oxygen, the following analysis being that of one of the best samples made in the district of Weissenfels: carbon 82·41, hydrogen 14·16, oxygen 3·43.

There are at the present time fourteen mineral oil and paraffin factories at work in the district, consuming about 30,000 tons of tar, 5,500 tons of caustic soda, and 2,900 tons of sulphuric acid, the products being—

12,500 tons benzine, photogene, petroleum, solar and clear paraffin oils
6,000 tons gas and lubricating oils
5,000 tons hard and soft paraffin
3,600 tons creosote, pitch, asphalt, and other accessory products

17,100 tons, equal to 75 per cent. of the weight of tar treated;

the remaining 25 per cent. representing the loss due chiefly to the production of gas and carbonisation by repeated distillations. About 3,500 tons of paraffin are converted into candles in the different manufactories.—L. Grzostowsky, *Zeitschrift für Berg-, Hütten- und Salinen-Wesen*, &c., vol. xxiv. p. 351. See Petroleum for the Use of the Mineral Oils as Fuel.

MINERAL SALT. (See Salt, vol. iii. p. 730.) The following notice of a new discovery of rock salt in Prussia will be of interest:—A discovery has recently been made at Aschersleben, in Prussia, in the vicinity of the Hartz Mountains. Within the last twenty years the Governments of Prussia and Anhalt have been deriving large profits from the working of sundry pits or mines productive of potash salts, situated at Stassfurth and Leopoldshall. Hitherto these undertakings have enjoyed a monopoly, but an independent party of explorers, aided by the diamond rock-boring apparatus, have succeeded in reaching the potash deposits at moderate depths not far from Stassfurth. The first boring reached what is called the 'kainit' portion of the potash layer, which was proved to have a thickness of 60 English feet. As the Prussian mining law entitles the discoverers to a concession equal to an area of 2,189,000 square mètres, it is computed that this discovery includes about 66,000,000 tons of potash salts. But the explorers, consisting chiefly of English capitalists, have proceeded further, and by means of other borings have obtained the command of an enormous area of these valuable deposits, which are now going to be extensively worked. The fertility imparted to the soil by the use of potash manure, renders the discovery a matter of interest to the agriculturist. Experience gained in Germany and Holland shows that by the use of the kainit and other forms of potash, land naturally poor can be made to bear extraordinary crops. This system of fertilisation has been found peculiarly advantageous in the case of peat lands and moors. See Salt.

MINERAL STATISTICS OF THE UNITED KINGDOM. The extent and importance of the mineral deposits of the British Isles, and the influence exercised by their development on the well-being and prosperity of the empire, will become

apparent by a consideration of the following tables, showing the number of mines in which each variety of mineral is wrought, the quantities and values of the minerals raised, and of metals produced therefrom; together with the imports and exports of each variety in the three years ending 1876.

Tin.—The earliest mining operations in this country were in search for this metal in the western counties of Cornwall and Devon, where it alone occurs in lodes, and is also found disseminated through the granitic rocks of the above-named counties. The annexed summary, obtained from the returns of the mines and the tin smelters, show the actual number of mines selling tin ore (black tin), the yield of metallic (white) tin, and the respective values:—

Year	No. of Mines	Tin Ore		Metallic Tin	
		Quantity	Value	Quantity	Value
		Tons	£	Tons	£
1874	230	14,039	756,310	9,942	1,077,712
1875	183	13,995	735,606	9,614	898,266
1876	185	13,688	600,923	8,500	675,750

The average prices of tin ore, in each of the above-named years, and of metallic tin (common block), was as follows:—

Year	Tin Ore	Metallic Tin
	£ s. d.	£ s. d.
1874	56 3 0	108 8 0
1875	52 11 6	90 2 0
1876	46 16 0	79 10 2

The production of the Dutch tin mines in each of the same years amounted to the following quantities:—

Description	1874	1875	1876
	Tons	Tons	Tons
Banca tin . . .	4,049	4,490	4,519
Billiton tin . . .	3,167	3,625	3,643
Straits tin . . .	7,577	11,300	9,621

Tin Imports.—The total quantities of tin imported into the United Kingdom in each of the same years were as follows, of blocks, ingots, bars, or slabs, and regulus, and of the annexed values:—

Year	Quantity	Value
	Cwt.	£
1874	184,377	904,488
1875	335,481	1,433,901
1876	304,448	1,148,164

Of the tin imported in the above years, the following quantities shipped from the Australian colonies to the mother-country are included in the general imports, and are as follows:—

Year	Tons	Year	Tons	Year	Tons
1874 .	6,800	1875 .	7,210	1876 .	6,392

Tin Exports.—The total quantities of British production exported in each of the years, and the respective values, appear in the *Trade and Navigation Returns* as follows:—

Year	Quantities	Value
	Cwt.	£
1874	154,613	510,652
1875	104,269	476,131
1876	99,941	396,076

The quantities and values of foreign and colonial tin exported in each of the same years was as follows:—

Year	Quantities	Value
	Cwt.	£
1874	47,378	235,081
1875	84,745	367,170
1876	105,008	399,008

COPPER, PRODUCTION.—The mines of the United Kingdom produced copper ore in the following quantities, the yield of metallic copper in each of the same years being as under:—

Year	No. of Mines	Copper Ore		Metallic Copper	
		Quantities	Value	Quantities	Value
		Tons	£	Tons	£
1874	119	78,521	336,415	4,981	447,891
1875	100	71,528	333,414	4,323	385,984
1876	101	79,252	317,156	4,694	392,300

The following average prices of different descriptions of metallic copper per ton will show the fluctuations to which this important metal was subject in each of the same years, and below, the average price, produce, and standard of the ores thus produced:—

Description of Copper	1874	1875	1876
	£ s. d.	£ s. d.	£ s. d.
Best selected . .	89 12 0	90 0 0	83 6 2
Tough cake and tile .	84 0 0	88 9 0	81 19 6
Sheeting and sheets	94 5 0	90 8 0	87 11 10
Australian . . .	89 0 0	91 6 0	83 3 3

Year	Average Price	Average Produce	Average Standard
	£ s. d.		£ s. d.
1874	4 5 0	7½	97 16 0
1875	5 0 0	7	110 0 0
1876	4 17 0	6¾	113 8 0

The copper ore and value, together with the yield of metallic copper and its value, will for the year 1876 be seen in the following statement, distinguishing the number of mines and the produce of each county:—

Counties, &c.	No. of Mines	Copper Ore	Value of Ore	Copper	Value of Copper
England.		Tons	£ s. d.	Tons cwt. qrs.	£ s. d.
Cornwall	65	43,016	202,203 2 9	3,634 0 0	
Devonshire	15	16,276	58,240 19 10	875 0 0	
Cumberland	1	11	120 10 0	2 0 0	
Cheshire	1	7,328	5,860 0 0	78 17 2	
Lancashire	1	1,007	6,414 0 0	91 4 2	
Wales.					
Cardiganshire	1	42	210 0 0	2 12 0	
Carnarvonshire	3	115	560 0 0	7 19 0	391,130 0 0
Merionethshire	1	1	5 5 0	0 1 2	
Montgomeryshire	2	47	228 0 0	3 6 0	
Anglesea	2	3,692	7,380 0 0	100 0 0	
Isle of Man.	1	75	363 15 0	3 17 0	
Scotland.	1	660	2,108 0 0	30 0 0	
Ireland.	7	6,816	32,539 0 0	449 0 0	
Regulus, &c.[1]	—	146	947 15 0	13 15 0	1,170 0 0
Total of the United Kingdom	101	79,252	317,186 7 7	4,604 12 3	392,300 0 0

Imports and Exports of Copper.—From the *Trade and Navigation Returns*, published by the authority of the Board of Trade, it appears the following quantities of the various descriptions of copper were imported into the kingdom in each of the following years:—

Description of Copper	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£
Copper ore	47,860	713,719	55,649	739,391	74,079	929,[illegible]
" regulus	26,496	1,063,301	32,906	1,000,440	37,975	1,026,316
" Old	1,808	77,800	1,497	65,431	2,640	101,293
" Unwrought, &c.	87,754	3,198,140	89,738	3,074,843	39,[illegible]	3,060,066
" manufactures	—	58,911	—	72,879	—	90,316

In each of the same years the exports of the various forms of copper, the produce of the mines of the United Kingdom, amounted to the following quantities and values:—

Description of Copper	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Cwt.	£	Cwt.	£	Cwt.	£
Unwrought in ingots, cakes, or slabs	214,091	942,420	223,073	890,164	238,229	948,421
Copper coin	4,129	24,166	1,461	9,348	87	912
Mixed or yellow metal for sheathing	281,158	1,170,630	277,549	1,084,724	255,074	950,407
Wrought or manufactured	206,068	1,080,952	228,928	1,163,297	216,330	950,316

Lead Ore, Lead, and Silver.—The production of the mines of the United Kingdom, and the yield of metallic lead and silver, was as follows in each of the years:—

[1] In this quantity is included sundry copper ores, the produce of the mines of Cornwall and Devon, sold at Ticketings.

Year	No. of Mines	Lead Ore	Lead	Silver
		Tons	Tons	Ozs.
1874	345	76,201	58,777	509,277
1875	304	77,746	57,425	487,358
1876	392	79,096	58,667	483,422
Values of the Above.				
		£	£	£
1874		1,024,107	1,298,463	127,389
1875		1,202,148	1,290,373	115,747
1876		1,218,078	1,271,415	106,222

During each of the same years the average price per ton of lead ore, and of metallic lead, was as follows in the London metal market:—

Description	1874			1875			1876		
	£	s.	d.	£	s.	d.	£	s.	d.
Lead ore	15	9	3	14	13	6	15	8	0
English pig	22	0	4	22	2	0	21	18	10
,, sheet	23	13	8	23	13	0	22	16	7
,, pig W.B. . . .	23	6	6	23	6	0	23	1	9
Patent shot	26	7	6	26	3	0	25	16	1

The details of production of the several lead-mining districts in the United Kingdom, with the number of mines in the year 1876, is as follows:—

Counties	No. of Mines	Lead Ore		Lead		Silver
England.		Tons	cwt.	Tons	cwt.	Ozs.
Cornwall	16	2,727	0	2,070	0	37,650
Devonshire	4	437	13	327	17	5,890
Somersetshire	2	578	0	301	8	—
Derbyshire	140	2,441	13	2,149	1	—
Shropshire	7	7,713	13	5,955	6	2,748
Cumberland	25	2,555	17	1,915	14	10,600
Yorkshire	23	4,198	15	2,969	9	8,850
Durham and Northumberland	28	23,285	9	16,730	3	74,095
Westmoreland	6	1,844	4	1,378	16	8,214
Wales.						
Cardiganshire	33	5,961	16	4,468	19	45,418
Carmarthenshire	1	636	15	477	10	1,910
Pembrokeshire	1	15	0	11	0	66
Radnorshire	1	71	4	52	8	—
Merionethshire	3	60	9	45	6	222
Denbighshire	9	3,247	6	2,463	6	13,246
Montgomeryshire . . .	80	9,041	8	6,878	11	67,414
Brecknockshire	2	35	8	26	10	130
Flintshire	35	2,716	19	2,016	1	13,151
Carnarvonshire	11	1,439	8	1,039	2	4,659
Isle of Man	10	4,353	1	3,056	1	170,105
Ireland	1	1,825	4	1,368	18	6,840
Scotland	4	3,910	4	2,936	6	12,214
Total of the United Kingdom	392	79,096	6	58,667	12	483,422

The Imports of Lead in the three years ending 1876 appear as follows in the *Trade and Navigation Returns* :—

Description of Lead Imported	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£
Lead ore	13,060	220,896	11,916	185,456	12,833	175,187
Lead, pig and sheet	61,987	1,411,365	79,420	1,801,045	80,649	1,749,974
Lead manufactures unenumerated	6,313	12,504	6,946	12,453	6,723	12,080

The Exports of Lead, the produce of the mines of the United Kingdom, are shown in the annexed summary for each of the same years :—

Description of Lead	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£
Ore	450	6,096	96	1,915	79	1,760
Lead	23,872	560,723	24,271	537,562	24,459	529,257
Rolled and sheet, &c.	10,841	261,119	11,157	252,541	11,463	251,726

ZINC.—The total quantities of zinc ores obtained from the mines of the United Kingdom in the three years ending 1876 are as follows—principally sulphide of zinc (Black Jack) :—

Year	No. of Mines	Zinc Ore		Zinc	
		Quantities	Value	Quantities	Value
		Tons	£	Tons	£
1874	64	16,829	48,195	4,470	106,773
1875	60	23,978	75,110	6,718	162,790
1876	57	23,613	90,142	6,641	158,011

The zinc ores obtained from the mines of the United Kingdom in the year 1876 were contributed by the several districts, as shown in the annexed Table. The values will be found side by side :—

Counties	No. of Mines	Quantities			Value		
England.		Tons	cwt.	qrs.	£	s.	d.
Cornwall	14	4,413	19	2	14,592	19	8
Shropshire	5	401	10	0	2,516	6	0
Cumberland	6	1,366	2	2	5,306	6	0
Yorkshire	1	3	10	2	10	11	6
Derbyshire	1	51	6	1	153	18	0
Wales.							
Cardiganshire	8	268	9	0	1,018	12	9
Montgomeryshire	4	2,781	18	0	10,549	1	0
Denbighshire	3	2,152	0	0	11,605	13	6
Flintshire	4	2,494	10	0	12,088	2	3
Carnarvonshire	5	300	8	2	1,433	12	9
Radnorshire	1	63	8	0	375	13	1

Counties	No. of Mines	Quantities			Value		
		Tons	cwt.	qrs.	£	s.	d.
Anglesea	1	7	0	0	9	7	9
Sundries—England and Wales .		175	0	0	393	15	0
Isle of Man . . .	3	8,669	6	0	27,932	1	3
Scotland.							
Kirkcudbrightshire . . .	1	348	0	0	1,756	0	0
Total . . .	57	23,613	8	1	90,142	0	6

In each of the same years the average price per ton of the ores, and of the various forms of metallic zinc, was as follows in the London market:—

Description	1874			1875			1876		
	£	s.	d.	£	s.	d.	£	s.	d.
Zinc ore . . .	4	2	3	3	7	6	4	12	0
English spelter . .	24	5	0	23	6	6	23	7	11
Foreign spelter . .		—			—		23	18	4
Sheet zinc . . .	30	14	6	29	12	3	28	2	3

Imports and Exports of Zinc.—The *Trade and Navigation Returns* give the following as the quantities and value of crude and manufactured zinc imported in each of the three years ending 1876:—

Year	Crude Zinc		Zinc Manufactures	
	Quantities	Value	Quantities	Value
	Tons	£	Tons	£
1874	22,216	492,874	12,630	372,176
1875	22,719	513,457	15,270	439,548
1876	29,466	666,234	19,719	411,536

The Exports of Zinc or Spelter, the production of British mines, were as follows in each of the same years:—

Year	Quantities	Value
	Tons	£
1874	3,793	194,490
1875	4,896	116,588
1876	5,656	130,206

Pyrites (*Mundic—Sulphur, and Arsenical Ores*).—Of these ores, the mines of the United Kingdom produced the following quantities in each of the years:—

Year	Quantities	Value		
	Tons	£	s.	d.
1874	56,208	38,226	16	10
1875	48,035	35,136	10	11
1876	48,809	43,870	1	7

In the next table appears the quantities and values of the sulphur ores produced from the mines of the United Kingdom in the year 1876:—

Countries	Quantities			Value		
England.	Tons	cwt.	qrs.	£	s.	d.
Cornwall	8,243	17	1	14,918	15	9
Devonshire	5,990	7	1	5,592	4	10
Durham and Northumberland . .	1,510	0	0	705	0	0
Lancashire	2,625	0	0	1,312	10	0
Staffordshire	2,870	0	0	1,435	0	0
Yorkshire	2,000	0	0	1,000	0	0
Sundries estimated	8,000	0	0	4,000	0	0
Wales.						
Glamorganshire	51	0	0	38	5	0
Carnarvonshire	896	0	0	672	0	0
Merionethshire	1	0	0	1	10	0
Anglesea	605	0	0	405	0	0
Ireland	16,017	10	0	13,792	16	0
Total . . .	48,809	14	2	43,870	1	7

Imports of Iron and Copper Pyrites in the three years ending 1876:—

Countries from which imported	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£
Norway	41,044	91,829	21,890	43,868	7,688	14,041
Portugal	162,869	449,914	165,432	453,703	56,879	164,316
Spain	294,117	709,580	344,019	863,703	419,068	985,431
Germany	—	—	—	—	11,241	19,516
Other countries	907	2,110	6,263	13,323	10,086	20,080
Total . .	498,937	1,252,333	537,585	1,406,965	504,573	1,204,799

Miscellaneous Minerals.—In the annexed table the quantities of the less important minerals obtained from the mines of the United Kingdom in each of the years ending 1876 are given:—

Minerals	1874			1875			1876		
	Quantities			Quantities			Quantities		
	Ozs.	dwt.	grs.	Ozs.	dwt.	grs.	Ozs.	dwt.	grs.
Gold	385	0	12	548	1	21	293	13	13
				Tons	cwt.	qrs.			
" quartz, and pyrites (estimated)	—			32	1	0	—		
	Tons	cwt.	qrs.				Tons	cwt.	qrs.
Silver and copper precipitate	2	10	0	64	7	2	1	0	0
Arsenic	6,268	9	3	5,061	5	1	4,228	1	0
Manganese	5,778	1	0	3,205	11	1	2,796	17	0
Wolfram	32	15	3	46	2	1	23	10	0
Bismuth	—			—				7	3
Fluorspar	634	10	0	358	18	1	337	10	0
Plumbago	—			20	0	0	1	0	0
Ochre and umber . . .	7,122	1	2	5,315	12	2	3,805	0	0

Pig Iron produced in Great Britain, and Coal used in its Manufacture.

Countries	1874 Pig Iron	1874 Coal used	1875 Pig Iron	1875 Coal used	1876 Pig Iron	1876 Coal used
England.	Tons	Tons	Tons	Tons	Tons	Tons
Northumberland . .	22,142	74,681	22,970	84,812 }	853,172	1,886,402
Durham . . .	839,335	1,983,087	786,906	1,822,420 }		
Yorkshire, N. Riding .	1,159,471	2,896,177	1,240,243	2,873,357	1,261,013	2,993,870
" W. Riding .	163,856	349,363	267,122	695,557	335,451	663,330
Derbyshire . . .	301,657	906,901	272,068	779,100	300,719	777,772
Lancashire . . .	488,672	930,840	528,780	956,002	562,984	991,377
Cumberland . . .	390,480	1,010,195	456,113	1,080,000	436,867	936,929
Shropshire . . .	126,953	394,004	120,964	370,000	106,771	334,738
North Staffordshire .	273,501	820,614	241,396	708,000	213,849	625,367
South Staffordshire .	452,400	1,209,216	470,540	1,283,880	465,946	1,282,063
Northamptonshire .	83,760	100,880	90,080	177,883	84,916	212,003
Lincolnshire . . .	67,366	167,196	111,082	302,000	126,128	297,676
Gloucestershire . .	43,139	137,418	37,089	87,061	28,106	80,318
Wiltshire . . . }						
Hampshire . . . }	35,115	91,323	52,731	93,573	29,473	65,983
Somersetshire . . }						
Total . . .	4,417,139	11,290,831	4,718,554	11,391,646	4,664,153	10,871,7[illegible]
North Wales.						
Denbighshire . . }	31,869	140,942	25,000	12,622	22,723	53,188
Flintshire . . . }						
South Wales.						
Anthracite furnaces .	23,780	87,340	29,888	61,169	20,421	52,997
Bituminous coal district:						
Glamorganshire .	350,484	668,760	249,067	631,036	321,754	690,558
Monmouthshire .	360,450	961,200	262,253	577,271	412,946	870,932
Total of North and South Wales . }	766,592	1,762,121	596,908	1,304,128	788,844	1,676,673
Scotland.						
Ayrshire . . .	240,667		358,164		360,934	
Lanarkshire . . .	501,341		631,495		680,074	
Fifeshire . . .	12,624					
Linlithgowshire . .	38,778	2,143,190 }	43,741	2,950,000 }		3,050,000
Stirlingshire . . }	16,837				63,000	
Argyleshire . . }			16,600			
Total of Scotland .	807,677	2,143,190	1,050,000	2,950,000	1,103,000	3,050,000

A summary of the foregoing returns shows the aggregate production of pig iron and coal used in its manufacture in the smelting operations to have amounted to the following quantities:—

Countries	1874 Pig Iron	1874 Coal used	1875 Pig Iron	1875 Coal used	1876 Pig Iron	1876 Coal used
	Tons	Tons	Tons	Tons	Tons	Tons
England	4,417,139	11,290,831	4,718,554	11,391,646	4,664,153	10,871,706
Wales	766,592	1,764,151	596,904	1,304,124	788,844	1,676,679
Scotland	807,677	2,143,190	1,050,000	2,950,000	1,103,000	3,050,000
Total . .	5,991,408	15,292,201	6,365,462	15,645,774	6,555,997	15,596,381

The following average prices show the fluctuations to which the several varieties of pig iron were subject to (per ton) in each of the same years:—

Description of Pig	1874	1875	1876
	£ s. d.	£ s. d.	£ s. d.
South Wales . . .	5 7 6	4 4 11	4 2 6
Scotland . . .	4 12 0	3 4 0	2 18 6
Cleveland . . .	3 15 6	3 0 0	2 13 0
Shropshire . . .	7 1 0	4 18 0	4 5 0
Northampton . .	4 9 9	—	—

The *imports* of all kinds of ore, iron and steel, into the United Kingdom, in each of the years ending 1876, appear as follows:—

Description of Iron	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£
Iron ore	784,141	1,021,461	458,673	583,571	672,235	798,510
Pig and puddled . . .	56,929	416,198	47,008	342,061	31,449	219,223
Bars	73,169	1,056,290	89,922	1,220,069	85,254	1,096,462
Old iron and steel . . .	22,121	121,431	19,394	86,732	16,664	56,939
Steel, unwrought . . .	7,334	128,390	7,500	119,224	9,220	129,843
Iron and steel, wrought and unwrought	1,054,019	1,325,776	1,130,762	1,422,739	1,390,325	1,434,531

The *exports* of iron of all kinds, the produce of the United Kingdom, in each of the same years, with the respective values, appear in the following tabular statement:—

Description of Iron	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£
Ore	1,092	1,801	2,458	3,864	642	906
Old for remanufacture . .	43,141	245,881	31,610	198,837	23,291	93,977
Pig	767,932	3,606,055	942,253	3,415,940	908,707	2,837,283
Puddled	6,154	65,646	5,473	33,930	3,008	15,132
Bar	221,473	2,899,670	238,866	3,043,108	133,767	1,662,031
Angle	6,209	83,037	9,290	83,397	6,162	57,[illegible]
Bolt and rod	30,969	371,840	29,192	298,318	24,018	226,315
Railroad, rails, and tie rods .	699,684	9,14[illegible]	490,741	4,618,452	368,478	3,086,790
Railroad, wheels and axles .	23,048	658,141	13,721	320,208	12,832	[illegible]
Railroad unenumerated . .	30,969	531,339	41,809	314,176	30,233	394,383
Sheet, boiler, and armour plates	76,311	1,326,457	88,253	1,339,308	87,490	1,242,838
Tin plates	127,950	3,714,810	138,263	3,694,807	132,564	2,[illegible]
Galvanised other than wire, &c.	54,358	877,796	60,198	1,227,745	43,518	1,038,[illegible]
Hoops	57,861	766,896	66,038	796,846	52,977	863,[illegible]
Wire of iron or steel except telegraph wire . . .	36,682	769,927	42,221	780,037	44,613	731,149
Anchors, grapnels, chains, and cables	24,213	852,894	24,236	478,293	19,710	[illegible]
Tubes and pipes, wrought .	25,408	643,348	35,[illegible]	330,243	23,028	444,912
Nails, screws, and rivets . .	16,101	534,872	17,106	538,221	15,799	472,530
Cast or wrought, &c., except ordnance	191,223	2,400,[illegible]	173,267	2,804,833	183,817	3,763,425
Steel in ingots	183	7,237	[illegible]	3,635	398	6,221
Steel, bar, of all kinds . .	26,[illegible]	1,004,[illegible]	26,727	970,400	23,113	799,223
Steel sheets	2,663	101,947	2,022	89,696	2,425	82,969
Manufactures of steel or steel and iron combined . .	10,[illegible]	701,908	11,[illegible]	837,730	10,243	787,127

Summary of the Collieries of the United Kingdom and of the Production of Coal.

Coal-fields	1874		1875		1876	
	No. of Collieries	Quantities	No. of Collieries	Quantities	No. of Collieries	Quantities
		Tons		Tons		Tons
Northumberland	179	6,403,660	170	12,640,780	156	12,880,000
North Durham		6,190,000				
Cumberland	94	1,105,207	80	1,226,787	27	1,421,808
Westmoreland	3	1,300	8		8	
South Durham	176	17,000,250	177	19,450,594	156	19,411,123
Cheshire	60	613,106	37	668,546	39	654,890
Lancashire, North and East	370	8,000,570	400	8,822,706	385	8,205,000
Lancashire, West	152	7,443,950	155	8,250,240	174	8,195,000
Yorkshire	551	14,812,610	552	15,490,279	563	15,005,570
Derbyshire	249	7,150,570	258	7,091,035	261	7,125,550
Nottinghamshire	49	3,127,750	46	3,250,000	48	3,416,100
Warwickshire	20	851,800	21	789,760	29	854,760
Leicestershire	24	1,100,465	25	1,164,610	27	1,035,000
Staffordshire, South, and Worcestershire	400	8,240,343	442	10,281,701	434	10,081,067
Staffordshire, North	150	4,310,000	157	4,450,210	153	4,077,548
Shropshire	63	1,157,000	64	1,229,785	64	1,054,042
Gloucestershire	69	1,147,272	80	1,210,080	89	1,307,647
Somersetshire	28	600,964	40	654,576	45	650,123
Monmouthshire	118	5,058,820	91	5,535,975	104	4,490,563
Wales, North	123	2,425,000	134	2,397,308	136	2,505,350
" *South*	371	10,194,580	416	10,632,097	400	11,070,330
Scotland, East	330	10,152,356	304	11,410,610	334	11,067,649
" *West*	354	8,606,355	295	7,177,893	239	6,997,504
Ireland	45	130,213	65	127,050	60	124,234
Total of the United Kingdom	3,873	126,067,916	3,933	131,867,105	4,099	133,344,766

Exports of Coal, Coke, Cinders, and Fuel manufactured.

Countries to which exported	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£
Russia	653,763	779,127	595,860	624,924	1,182,894	694,360
Sweden and Norway	880,807	785,389	1,136,100	749,254	1,160,958	642,440
Denmark	662,298	623,185	740,300	467,288	777,207	401,429
Germany	2,057,029	1,630,885	2,172,384	1,272,894	2,271,901	1,190,834
Holland	447,671	398,010	550,864	304,295	478,983	275,052
France	2,070,661	1,676,158	2,704,210	1,617,038	2,250,290	1,005,771
Spain and Canaries	581,413	582,408	693,100	422,900	789,821	461,434
Italy	966,128	832,147	1,000,453	647,056	1,226,308	640,342
Turkey	311,361	280,850	342,408	178,485	394,314	194,536
Egypt	629,276	600,782	633,409	405,800	540,039	323,565
Brazil	328,387	300,843	304,857	200,517	387,694	217,634
Malta	212,029	209,298	219,077	133,079	254,658	154,008
British India	653,046	603,257	614,844	456,838	780,162	468,770
Other countries	3,736,800	2,452,724	3,749,900	1,965,110	2,945,308	1,700,783
Total	13,927,200	11,934,021	14,844,018	9,658,088	16,365,830	8,901,710

Coal, &c., shipped for the use of Steamers engaged in the Foreign Trade.

	1874		1875		1876	
	Quantities	Value	Quantities	Value	Quantities	Value
	Tons		Tons		Tons	
Coals, &c., shipped	3,140,283	Not given	3,376,340	Not given	3,564,624	Not given

FRANCE.—*The Mineral Industry of France for 1875.* The following are the only returns which can be obtained. The statistical returns are usually only published once in five years:—

Combustible Minerals.

	Quint. met.	Total
Coal	154,701,485	
Anthracite	10,444,471	= 169,400,315
Lignite, &c.	4,254,359	

Iron, &c.

	Quint. met.
Cast iron	14,157,263
Wrought iron	7,554,422
Steel	2,516,374

ITALY. *Table showing the Exportation of Mineral Products from Italy for the Year* 1875, *furnished by Chevalier* JERVIS *for this work.*

Products	Quantity exported to Great Britain alone		Total Quantity exported		Value
	Tons of 1,000 kilogrammes	Number	Tons of 1,000 kilogrammes	Number	£
Regulus of antimony . .	100	—	100	—	8,000
Metallic antimony . . .	10	—	11	—	433
Mercury	104	—	140	—	27,920
Iron ore	4,039	—	191,157	—	53,444
Copper ore	6,068	—	9,069	—	57,986
Lead ore	5,155	—	18,467	—	221,604
Zinc ore	15,428	—	64,501	—	167,702
Manganese ore . . .	436	—	3,304	—	26,431
Graphite	—	—	620	—	1,247
Raw sulphur	64,293	—	215,144	—	1,161,778
Refined and sublimed sulphur; flowers of sulphur . .	—	—	1,556	—	18,700
Solid and liquid bitumen .	—	—	900	—	13,440
Boracic acid	2,355	—	2,461	—	147,684
Salt (sea salt and rock salt) .	22,874	—	118,464	—	35,163
Ochres, raw and burnt . .	121	—	234	—	707
Grind-stones	—	57	—	483	9,706
Mill-stones	—	—	—	1,250	4,503
Hones, flints, soapstone for tailors	100	—	402	—	21,322
Slates	3	—	820	—	3,280
Plaster of Paris . . .	—	—	946	—	2,303
Alabaster in blocks . .	132	—	637	—	2,040
Sculptured alabaster and plaster casts	—	—	—	—	38,400
Marble in blocks . . .	14,204	—	63,345	—	153,026
" in sawn slabs not polished . . .	—	43,601	—	273,180	100,004
" in polished slabs .	—	—	—	22,299	12,591
" baths, mortars, marble mill-stones . .	—	—	—	—	10,132
" in slabs for pavements	—	—	—	37,800	33,540
" cornices, steps, banisters, &c., for building purposes . .	—	—	—	—	4,077
" sculptured, or otherwise artistically worked . . .	—	—	—	—	147,346
Total of the above products exported in the year 1875					2,485,521

N.B.—In addition to these there are sundry products not defined sufficiently in the Custom House statistics to be able to include them here. The total mineral production

of Italy also includes the home manufacture and consumption, of which a general idea may be formed from the following notes.

Notes to the foregoing Table.

MERCURY.—Two mercury mines are still extensively worked, in spite of the wonderful fall in the price of this metal since the discovery of important deposits in North America (in the provinces of Sienna and Belluno).

IRON ORE.—The exportation is almost exclusively confined to the mines in the island of Elba, and the neighbouring ones at Monte Argentario (Grosseto). A very large quantity of iron is likewise smelted in Italy, both for the manufacture of cast and wrought iron and steel. The most extensive iron mines are those of Elba (Leghorn), the produce of which in the year 1873–4 was 221,850 metrical tons; other mines exist in Central Italy, near Campiglia Marittima. In the Alpine region the principal mines are found at Montaldo di Mondovi (Cuneo), in the Val d'Aosta (Turin), the Val Brembana, the Val Seriana, the Val Camonica, and the Val Scalva (Brescia and Bergamo); finally in the Valtellina (Sondrio). Italian iron is principally manufactured in the mountainous districts, the ore being smelted with charcoal and the iron puddled with lignite: SIEMENS' gas furnaces have been long in use and with the greatest success. The employment of charcoal is a pure folly, as the destruction of the forests entails the destruction of the entire mountainous districts of the Alps, and causes the most formidable expense to the nation on account of the periodical inundations which are the inevitable consequence. Palæozoic anthracitic coal exists in the provinces of Cuneo, Turin, and Udine, and would be admirably adapted for iron smelting, being free from sulphur. BESSEMER steel is manufactured at Piombino (Pisa). Owing to the development of the iron manufacture in Italy the exportation of the ore represents but a tithe of the total production.

COPPER ORE.—Large copper-smelting works have been in existence for many years near Prato (Florence); smaller ones are also to be found in the provinces of Lucca and Grosseto, where the ore is either concentrated into a rich matt or smelted. In the Val d'Aosta (Turin) numerous copper deposits are known; a few mines are still worked, but with total absence of spirit; the capital employed in them is also insignificant. The ores from these mines are partly concentrated and exported as a matt partly smelted on the spot.

LEAD ORE.—The lead mines of Italy are in a very flourishing condition. First in importance is unquestionably that of Monteponi (Cagliari), one of the best, indeed, in Europe. Gennamari and Ingurtosu mine, situated not far from it, also produces vast quantities of rich ore. Lead mines are abundant in every part of the island of Sardinia (Cagliari and Sassari); several of them are very large, and, what is more, admirably directed. In the Peninsula the Bottino mine (Lucca) holds the first rank, and is a model of good working: the ore is exceptionally rich in silver. Lead mines are at work in various parts of the Alps (Novara, Milan, Como). Excellent lead-smelting works are established at the Bottino mine; at Portosolo, near Spezia (Genoa), where a large proportion of the ores from the provinces of Cagliari and Sassari are smelted; at Genoa, &c. Only a small proportion of the lead ore produced in Italy is exported.

ZINC ORE.—This mineral is principally worked in the provinces of Grosseto and Belluno, the former being situated in Central Italy, the latter in the Carnic Alps: the mines in the province of Belluno are close to the Austrian province of Carinthia, whence the ores are chiefly exported and smelted at Cilly and Sagor, in Styria.

MANGANESE ORE.—Manganese is raised in a rather desultory manner in numerous localities in the provinces of Genoa and Sienna, as also in the Val d'Aosta (Turin); it is principally exported to the South of France for glass manufacture.

GRAPHITE is produced in the Cottian Alps, being found in relation to the pre-palæozoic or secondary gneiss (Turin).

SULPHUR.—There are in Italy two distinct centres of production of sulphur: Sicily (Catania, Caltanisetta, and Girgenti), on the southern side of the island, and in two or three localities on the north side (Palermo). As a general rule these mines are literally rabbit-warrens, and are conducted in an antediluvian manner. Of late some large capitalists have introduced great improvements, and as they have erected proper machinery and employ engineers to superintend the undertakings, the mines are well worked. Great benefit will accrue to the sulphur mines of Sicily through the opening of national roads, as hitherto only mule tracks existed: railways are also being made in every direction and ports systematised at a fabulous cost to the central government. By all these means the price of carriage from the mines to the vessels will be diminished about four-fifths, and personal security be increased every year. Extensive sulphur mines are worked between Bologna and Ancona, in Central Italy (Pesaro and Urbino, Forli); several important companies are actively engaged in opening out the ground:

the produce is refined in the neighbourhood, chiefly at Rimini. Sicilian sulphur cannot bear any comparison with that of Central Italy, which is incontestably superior and purer, and sells at a much higher price in the market. All the sulphur mines in Italy belong to stratified marine deposits of the miocene or middle tertiary formation. Though sulphur is also one of the products of volcanic action, it must not for a single moment be supposed that the mineral extracted in any part of Italy has the remotest relation to volcanic phenomena, as seems to be still the opinion of some English geologists. Sulphur is consumed in large quantities in the country itself for the manufacture of gunpowder and chemical works, but chiefly in the ground form for sulphuring vines, in order to ward off the cryptogama.

Bituminous Schist and Petroleum are widely represented in the miocene formation throughout the Peninsula and the island of Sicily, but the quantity is far too insignificant to make it an article of extraction, except in the western spurs of the Apennines, near the valley of the Pescara (Abruzzo Citeriore), where mining enterprise has been very successfully directed to the working and purification of petroleum, bitumen, and asphalte. Other mines are just now being opened on the Mediterranean side of the Apennines between Rome and Naples (Terra di Lavoro). Asphalte is principally manufactured at Milan, while the mineral oils are refined for the most part at Vicenza; but a small part of all these products is exported.

Boracic Acid is especially interesting as an object of extraction in Italy. It is found in the neighbourhood of Volterra (Pisa), all along the course of a valley, consisting of upper cretaceous and tertiary rocks, in the midst of which active chemical decomposition is set up the moment water comes in contact with numerous minerals in unstable chemical union which exist at a certain depth, and of which the principal contain boron in some state of combination hitherto unknown. The method of procuring the acid is extremely simple and beautiful, reducing itself to the formation of small circular lagoons, secured by a low wall in dry masonry, and then making an artesian boring in the centre. Surface water is constantly furnished to the lagoons, and, penetrating the deep fissures in the rock, determines the formation of soluble boracic acid, which is ejected with the water, and raised to the boiling point by the intensity of the chemical action. A practical theory attributed the origin of the boracic acid lagoons to volcanic action at a vast distance from its centre of activity. More accurate study of the phenomena shows that there is not the slighest ground for such a gratuitous supposition.

Salt is found in three states: in Sicily, Calabria, and south of Leghorn as rock salt. In numerous localities the saline mineral springs are rich enough to be utilised for the evaporation of the salt. This substance is likewise extracted in immense quantities from sea water, the great heat and long duration of the summers in the South of Europe being peculiarly favourable to an exceptionally great amount of evaporation. Being an article of Government monopoly, the price of salt for home consumption is very high, and the quantity used is consequently reduced to the lowest terms.

Mineral springs are very abundant in Italy, where there are about 1,000 of great importance, besides at least 600 others more or less insignificant. They belong to the following classes: saline, saline-iodine, saline-alkaline, acidulous, acidulo-chalybeate, sulphurous and sulphuro-hydrocarburated springs. Their temperature ranges between 43° and 212° Fahr., and is remarkable for its constancy. Geologically speaking, the greater number rise in the miocene strata of marine origin; a few also exist in the palæozoic rocks of the Alps; those which originate in rocks formed by active and extinct volcanos possess peculiar medical efficacy. Singularly enough, the former are cold, the latter hot. The springs which originate at great depths are often cold; those which are formed only a few fathoms below the surface, as at Ischia, are often near the boiling point. The mineral springs of Italy were held in the highest repute by the Romans. Commercially speaking, now-a-days, the waters of Italy are only beginning to be known and duly appreciated, so that they do not yet form an article of export. Vast thermal bathing establishments exist in many places, of which the following may be mentioned:—Acqui, Bormio, Recoaro, Abano, Porretta, Montecatini di Val di Nievole, Ischia, Acireale. It would be a very easy matter with proper private enterprise to make the mineral springs of Italy bring in a revenue of 400,000*l.* per annum.

Ochres used as pigment are chiefly found in the neighbourhood of the Monte Amiata (Sienna), and in the island of Elba. In addition to the exportation of this product, so well known in trade by the name of Sienna earth, it is largely consumed in the country for a variety of purposes.

Slate of the best quality is quarried near Chiavari (Genoa), and is extensively employed for roofing in Liguria; this useful stone is also found at Stazzema (Lucca), but it does not possess so perfect a cleavage or so polished a surface as that from the foregoing locality.

Gypsum for plaster of Paris is found in the miocene rocks throughout Italy; that

of the mesozoic period is far more esteemed, as being stronger: of this latter kind quarries are worked in the provinces of Grosseto, Cuneo, &c.

ALABASTER, that queen of ornamental stones, is found at small depths below the surface in the form of rounded masses in the miocene clays of Central Italy (Pisa). Its extraction and subsequent working into statuettes and ornaments of fairy-like beauty and the most delicate transparency, gives employment to a very considerable number of persons, for the most part skilled artisans. Artistic productions in alabaster, which are sent to every part of the civilised world, are almost exclusively made in Italy at Volterra, Pisa, and Florence.

MARBLES.—Italy possesses a larger variety of excellent marbles of every colour than any other country. Yellow marbles are extensively quarried near Monte Arenti (Sienna); black marble near Pisa; black with splendid gold-yellow veinings at Spezia (Genoa). Crystalline marbles are quarried on an immense scale at Carrara, Massa-Carrara, and Scravezza, three distinct centres of production. The greater part is pearl-grey: this is the best and strongest for architectural purposes. Snow-white marble is much weaker, and cannot bear exposure to the air. Snow-white marble with slate-grey veinings is principally employed for furniture and interior decoration. Statuary marble is either white or has an almost imperceptible tinge of yellow, which, as it imitates to perfection the colour of the skin, is highly prized and often sells for fabulous prices. White crystalline marble of precisely identical nature and origin is found at Valdieri (Cuneo), Masselo, and Prali (Turin), and other localities in the Alps. Geologically the white crystalline marbles of the Carrara district and the Alps belong to the pre-palæozoic rocks, below the Silurian formation, and result from the metamorphosis of slate-grey and other dark-coloured limestones. The same observation holds good with marbles as with the foregoing substances. The exportation of marble in its natural state or variously worked, including statuary, represents a value of 460,000*l.*, in addition to which there is a very considerable consumption in the kingdom itself.

PRUSSIA, *Mineral Production of*, 1871–1875.—The following statistics of mineral production in the kingdom of Prussia are from the official returns published in the *Zeitschrift für Berg-, Hütten- und Salinenwesen im Preussischen Staate*:

Minerals	Production 1871	1872	1873	1874	1875
	Centner (110·231 lb. avoirdupois)	Centner (110·231 lb. avoirdupois)	Centner (110·231 lb. avoirdupois)	Centner (110·231 lb. avoirdupois)	Centner (110·231 lb. avoirdupois)
I. *Mining.*					
a. Coal and Bitumen.					
1. Coal	519,340,873	580,476,619	648,958,163	636,773,685	663,386,080
2. Brown coal (lignite)	127,524,903	148,000,730	150,756,049	174,839,998	166,808,193
3. Asphalte	—	—	345,000	478,564	410,000
4. Naphtha	—	—	700	770	770
Total	650,865,777	730,468,349	807,060,803	812,682,193	833,001,941
b. Ores.					
1. Iron	58,405,192	72,427,382	71,100,106	50,917,374	61,[illegible],481
2. Zinc	6,613,058	8,534,313	8,822,920	8,870,503	9,304,103
3. Lead	1,843,658	1,803,574	1,921,361	1,992,001	2,167,357
4. Copper	4,280,299	5,586,348	5,700,181	6,108,031	6,479,003
5. Silver and gold	368	313	118	111	110
6. Quicksilver	140	30	—	—	—
7. Cobalt	301	4,373	5,713	5,080	4,000
8. Nickel	123	267	947	9,164	4,443
9. Antimony	315	309	341	220	308
10. Arsenic	8,300	12,044	68,041	46,849	40,058
11. Manganese	332,832	383,418	329,440	243,707	341,186
12. Iron pyrites	3,719,488	2,256,369	2,062,767	2,035,026	2,479,534
13. Miscellaneous ores, vitriol and alum ores		541,353	540,007	626,750	644,470
Total	74,118,600	93,843,534	91,001,908	70,870,050	78,843,412
c. Mineral salts.					
1. Rock salt	1,473,164	1,890,784	1,875,479	1,837,365	1,998,157
2. Nitre	3,203,000	3,650,500	3,372,000	2,320,000	2,263,221
3. Sulphide of magnesia	—	500	601	566	619
Total	4,676,164	5,547,784	4,847,910	4,098,134	4,561,007
Total mining products	730,660,410	837,949,340	902,060,420	887,652,090	915,718,850
II. *Saltworks.*					
Domestic salt	3,726,660	3,862,352	3,853,574	4,300,664	4,358,611

Minerals	Value in				
	1871	1872	1873	1874	1875
I. *Mining.*	Mark of 10¾d.	Mark of 10¾d.	Mark of 10¾d.	Mark of 10¾d.	Mark of 10¾d.
a. Coal and Bitumen.					
1. Coal	182,742,906	253,056,484	354,163,868	337,404,522	294,592,661
2. Brown coal (lignite) . .	20,897,789	22,571,375	27,856,027	31,467,845	28,263,421
3. Asphalte	—	—	181,500	307,809	246,000
4. Naphtha	—	—	24,840	24,840	24,840
Total . . .	203,641,695	279,227,859	382,227,723	369,204,016	324,126,822
b. Ores.					
1. Iron	23,437,423	34,167,730	33,896,990	19,094,350	19,300,511
2. Zinc	6,562,910	8,494,107	12,400,821	10,040,739	12,023,620
3. Lead	14,074,347	14,679,260	17,076,919	18,126,250	20,617,294
4. Copper	3,367,513	6,834,326	7,124,100	6,951,010	6,611,307
5. Silver and gold . . .	162,720	69,338	63,662	101,784	71,040
6. Quicksilver	189	177	—	—	90
7. Cobalt	17,015	26,189	55,291	142,028	19,146
8. Nickel	10,701	18,042	15,510	15,226	15,411
9. Antimony	900	2,183	2,100	1,663	2,405
10. Arsenic	15,860	4,023	54,492	55,175	62,000
11. Manganese	404,100	695,898	893,190	680,831	653,240
12. Iron pyrites	1,410,329	1,830,768	2,757,453	2,429,341	2,570,449
13. Miscellaneous ores, vitriol and alum ores . . .		37,760	160,898	148,320	48,177
Total . . .	52,841,309	67,242,018	74,613,270	58,731,424	63,790,427
c. Mineral salts.					
1. Rock salt	602,050	662,410	796,106	601,002	384,411
2. Nitre	1,218,868	2,150,460	1,601,145	977,392	1,297,872
3. Sulphate of magnesia . .	—	30,000	29,177	27,510	34,238
Total . . .	1,878,918	2,842,875	2,426,428	1,606,058	1,771,521
Total mining products .	258,339,855	349,310,152	459,166,026	429,602,520	345,390,640
II. *Salinoris.*					
Domestic salt	4,723,706	5,015,982	5,140,009	5,842,258	4,003,071

Nova Scotia.—*Mineral Production in 1876.*

Coal	709,646 tons
Gold	12,039 ounces
Iron ore	15,274 tons
Manganese	16 "
Copper	45 "
Lead	6 "
Gypsum	80,920 "
Freestone	5,905 "
Limestone	1,004 "
Moulding sand	227 "

—*Report of the Inspection of Mines in Nova Scotia for the year ending December* 1876, *by* Henry S. Pool, F.G.S.

MINES OF ENGLAND AND WALES. *Rateable value.*—The table on p. 588 is taken from a return to an order of the Honourable the House of Commons, dated March 15, 1877, showing the gross estimated rental and rateable value of the several coal, ironstone, and other mines in each Poor Law Union in England and Wales, together with the basis or mode of assessment. It will be seen that there is not an exact agreement between this return and that which follows under the head of Mines in the United Kingdom—especially in the collieries. This probably arises from the first return giving actual collieries only, whereas in the second some pits may have been returned as collieries. It is to be regretted that a more uniform system is not adopted by the Inspectors of Collieries in their returns. At present, and for some years past, the variations have been considerable; some of the inspectors giving the number of *pits* in their inspection district, others confining themselves to collieries.

County	1.—Coal Mines			2.—Ironstone Mines			3.—Other Mines		
	Number	Aggregate Gross Estimated Rental	Aggregate Rateable Value	Number	Aggregate Gross Estimated Rental	Aggregate Rateable Value	Number	Aggregate Gross Estimated Rental	Aggregate Rateable Value
England.		£	£		£	£		£	£
Chester	27	20,772	15,900	—	—	—	18	1,153	975
Cornwall	—	—	—	21	1,060	1,073	100	30,534	30,804
Cumberland	46	65,470	51,998	30	174,562	135,141	9	40,951	34,939
Derby	158	116,053	94,037	6	2,106	1,817	5	2,334	2,004
Devon	—	—	—	5	409	326	60	10,789	10,077
Durham	290	741,317	583,621	3	820	779	21	17,693	17,005
Gloucester	78	34,010	30,025	—	—	—	7	2,079	1,781
Lancaster	504	510,262	470,453	30	98,481	98,464	3	304	283
Leicester	13	21,256	19,154	—	—	—	—	—	—
Lincoln	—	—	—	1	984	954	—	—	—
Monmouth	151	98,468	84,004	22	3,001	2,637	—	—	—
Northampton	—	—	—	15	10,108	9,150	—	—	—
Northumberland	118	226,287	172,347	2	673	496	7	6,017	6,015
Nottingham	56	112,042	92,430	—	—	—	3	540	430
Salop	52	31,332	27,209	17	4,883	4,341	1	625	621
Somerset	39	22,077	20,658	3	1,088	1,059	1	40	36
Stafford	292	251,729	200,465	57	37,173	31,071	26	2,021	2,291
Warwick	15	14,968	11,172	2	786	371	—	—	—
Westmoreland	1	77	64	1	100	100	5	2,481	2,481
Wilts	—	—	—	—	—	—	48	5,420	4,875
Worcester	154	94,077	78,571	58	5,473	4,048	42	7,288	6,364
York (North Riding)	2	470	423	47	162,671	131,603	18	7,022	6,423
York (West Riding)	433	479,491	405,182	47	10,265	6,524	48	6,331	6,263
	2,220	2,874,311	2,344,204	323	311,145	252,990	485	145,012	120,062
Wales.									
Brecon	—	1,760	1,760	—	1,233	1,233	—	—	—
Cardigan	—	—	—	—	—	—	37	6,827	6,768
Carmarthen	63	20,715	16,311	—	—	—	7	978	862
Carnarvon	—	—	—	—	—	—	5	1,292	1,217
Denbigh	32	24,206	21,324	8	181	181	13	4,878	4,340
Flint	41	20,229	13,042	8	434	434	8	2,964	2,656
Glamorgan	310	423,123	366,001	47	8,109	6,210	2	88	76
Merioneth	—	—	—	—	—	—	19	26,008	23,748
Montgomery	4	570	653	—	—	—	20	10,958	10,892
Pembroke	11	3,144	2,475	3	82	72	6	182	167
Radnor	—	—	—	—	—	—	1	80	80
	468	516,788	425,028	63	10,060	8,190	108	66,321	62,342
Total of England and Wales	2,688	3,390,099	2,770,020	386	321,204	258,150	593	211,333	182,804

SUMMARY :—

Number of collieries—

England	2,220
Wales	468

Number of Ironstone mines—

England	323
Wales	63

Number of other mines—

England	485
Wales	108
Total number	3,667

MINES IN THE UNITED KINGDOM, DEPTHS OF. (Vol. iii. p. 257.) See BORING, in this volume.

The number of mines at work in the United Kingdom in the years 1875 and 1876 was as follows:—

Description of Mines	Number of Mines 1875	Number of Mines 1876
Tin	183	155
Copper	100	101
Lead	304	302

Description of Mines	Number of Mines 1874	Number of Mines 1876
Zinc[1]	60	57
Pyrites[2]	30	38
Gold	1	2
Arsenic[3]	31	25
Manganese	9	7
Wolfram	1	1
Plumbago	1	—
Iron ore	400	240[4]
Collieries	3,932	4,022

The *Returns* made to the Inspectors under the 'Coal Mines Regulation Act' show that in 1876—

The number of persons employed in our coal mines underground was .	409,229
Do. do. aboveground was .	105,303
Of the latter, 6,055 were females.	
The fatal accidents in 1876 amounted to	830
The number of deaths occasioned thereby	933

The *Returns* made under the 'Metalliferous Mines Regulation Act' give—

Persons employed	57,497	
In Great Britain—underground		32,795
" " aboveground		22,374
In Ireland—underground		1,314
" aboveground		1,014
The fatal accidents in 1876 amounted to	66	
The deaths from them amounted to	70	

The Depths of Mines.

Under Boring (pp. 152, 153), the depths of the deepest collieries and other mines, and of artesian wells, are given.

The following list refers to metalliferous mines in these islands only:—

Cornwall.

Consolidated Mines, copper (*not working*) .	from surface	312 fms.	= 1,872 feet
Dolcoath, tin and copper	"	371 "	= 2,226 "
(Perpendicular depth, 2,040 feet; the remainder on the line of the lode.)			
Tresavean, tin and copper (*not working*) .	from surface	350 fms.	= 2,100 feet
South Francis, tin and copper . . .	"	223 "	= 1,338 "
Cook's Kitchen, tin and copper (*not working*)	"	340 "	= 2,040 "
Botallack, tin and copper	from sea level	250 "	= 1,500 "
(Worked out under the sea for 2,448 feet.)			
Wheal Agar, tin and copper . . .	from surface	222 fms.	= 1,332 feet

The principal mines in the parish of Tavistock have the following main shafts:—

East Pool, copper	from surface	210 fms.	= 1,260 feet
Carn Brea, tin and copper . . .	"	315 "	= 1,890 "
South Carn Brea, tin and copper . .	"	176 "	= 1,056 "
South Wheal Crofty, tin and copper . .	"	210 "	= 1,260 "
St. Ives Consols, tin and copper . . .	"	203 "	= 1,218 "
(The shaft from surface was 193 fathoms, and a sump winze was sunk on the counter lode 8 fathoms deeper).			
West Seaton, tin and copper . . .	from surface	180 fms.	= 1,080 feet
South Caradon, tin and copper . . .	"	275 "	= 1,650 "
Phœnix, tin and copper	"	245 "	= 1,470 "
Marke Valley, tin and copper . . .	"	183 "	= 1,098 "
East Caradon, tin and copper . . .	"	164 "	= 984 "
Glasgow Caradon, tin and copper . . .	"	90 "	= 540 "

Devonshire.

Devon Great Consols (*Main Lode*).

Wheal Maria. . .	Gard's shaft	95 fms. deep
	Morris's shaft	100 "

[1] These are mines producing zinc as the more abundant ore.

[2] These do not include the pyrites, mundics, or coal-brasses, produced from tin or copper mines or from collieries.

[3] These are mines producing arsenical pyrites.

[4] In 1876 many ironstone pits worked in the coal measures are included, which are omitted in 1874.

Wheal Fanny	Western shaft	135 fms. deep
	Eastern shaft	80 "
Wheal Anna Maria	Engine shaft	137 "
Wheal Josiah	Field shaft	137 "
	Richard's shaft	200 "
	Hitchins's shaft	170 "
	Agnes's shaft	184 "
Wheal Emma	Incline shaft	205 "
	Thomas's shaft	210 "
New South Lode	Engine shaft	130 "
	Railway shaft	160 "
	New shaft	190 "
Wheal Thomas Lode	Western shaft	100 "
	Eastern shaft	40 "

(All these mines and lodes are comprehended within the sett of Devon Great Consols.)

BEDFORD UNITED.

Main Lode	Engine shaft	115 fms. deep
	Western shaft	130 "
	Incline shaft	143 "
North Lode	Engine shaft	138 "

SOUTH BEDFORD.

Main Lode	Engine shaft	49 "
	Gard's shaft	95 "
	Luscombe Down shaft	80 "
Impham Lode	Engine shaft	54 "
Wheal George and Charlotte	Engine shaft	40 "
	Lay's shaft	110 "
	William and Mary engine shaft	84 "
	" " whim shaft	70 "
East Wheal Russell	Hitchins's shaft	100 "
	Homersham's shaft	160 "

WHEAL RUSSELL.

Main Lode	Western shaft	37 fms. deep
	Hitchins's shaft	20 "
	Matthews's shaft	26 "
Impham Lode	Matthews's shaft	60 "
Bedford Consols	Whim shaft	57 "
Crowndale	Engine shaft	90 "
Wheal Crebor	Rundle's shaft	66 "
	Gill's shaft	40 "
	Kelly's shaft	130 "
	Cock's shaft	120 "
Wheal Gawton	Engine shaft	90 "
Wheal Crelake	Engine shaft on copper lode	116 "
	" " lead lode	62 "
Wheal Friendship (*in the parish of Mary Tavy*)	Old sump shaft	220 "
	Buller's shaft	220 "
	Taylor's shaft	240 "
	Brenton's shaft	100 "

Wheal Betsy (*in the same parish*).—Sunk by the Messrs. TAYLOR to the 110 fathom level, and deepened of late years by a Glasgow company about 20 fathoms.

YORKSHIRE, CUMBERLAND, &c.—The lead mines of the North of England are usually worked by levels, or tunnels driven into the hill at its lowest point, and then the mineral lode is followed up into the hill or worked 'upon the rise.'

The following account of the chief workings in the Alston Moor are contributed by Mr. W. WALLACE, whose excellent work on the metalliferous deposits of Alston Moor is deserving of a more attentive study than it has received.

ALSTON MOOR.—Nentforce Level is the longest level in Alston Moor; altogether it extends nearly five miles. The portion between Haggs Vein and Alston is an underground canal, and from Haggs Vein to Rampgill Vein it is made as an ordinary level at an elevation of about 180 ft. above the canal portion.

Rampgill Level extends from the Nent river to the boundary between Cumberland

and Northumberland, and is a little over a mile long. The branch in Scaleburn Vein extends to the same boundary. In each case the level is made near to or in the vein. Another branch of Rampgill Level extends southward from Rampgill Vein, near to or in Small Clough Vein. This extension is upwards of a mile long. In addition to these main trunks there are several other portions or branches which can only be shown properly upon a plan.

The Dowgang Level is very nearly on the same elevation as Rampgill Level. It is driven westward in the Dowgang Veins, and southward in, or near, to Black Ashgill Cross Vein, through that portion of the vein a little below Priorsdale Dam. Its extent in this direction is nearly two miles. It is also made in Middle Clough Second Sun Vein and Long Clough Veins, to a short distance from Carr's Cross Vein.

Browuley Hill or Broomsbury Low Level commences at the house near to the termination of the wood Greenends. It is extended to the Cross Vein, and from thence to and through a portion of Scaleburn Vein. In this direction the level must be 1½ miles long. It is also ramified through the whole extent of the Browuley Hill veins.

Browngill Low Level commences at Garrigill Burn, a little on the west side of the outcropping of the Scar limestone. It terminates near the middle of Browngill Sun Vein; and, on the course of the level, is about one mile long. The Rodderup Fell Levels are about the same extent as the above. These are the longest levels in Alston Moor.

The extent of the mine works on the range of the veins, from the Tyne river near Garrigill Village to Swinhope Burn in Northumberland, is remarkable. The Browngill mines, all the Nenthead mines, Dowgang, Browuley Hill, and the Coal Clough mines, are connected by mine works. Even at the present time, a person might enter the mines near the Tyne River, and pass through the whole extent of the above mines, without ever seeing the light of day—a distance as the crow flies of about seven miles. The Swinhope mines are connected with the Allenhead mines; the Garrigill and Nenthead mines are connected by mine works with the Weardall Pasture Grove mines, which are very extensive.

The deepest mine works, by which lead has been profitably raised in Alston Moor, is near the Northumberland boundary and in Rampgill Vein. It does not, however, much exceed 120 fathoms. At this place the Millstone Grit rocks only became productive at a depth of some 30 fathoms below the surface. The Long Clough Veins are worked some 80 fathoms below the surface. The firestone stratum, which is near the surface, contained no lead of importance, and the production of lead was limited to a section of about 35 fathoms, the lower part of which, in the Quarry Hazle, was not rich. Generally, profitable mining in Alston Moor has ceased at the bottom of the great limestone. Though there have been some rich deposits of lead in strata below the great limestone, yet if we take into consideration the cost of all the works made to find lead in these lower beds as they are called, the cost of production has very greatly exceeded the value of all the lead that has ever been produced from them. Three-fourths, at least, of all the lead that has been produced from the Alston Moor mines, has been raised from a section of about 150 feet, which comprehends the great limestone coal sills and little limestone.

It is only in the Tyne bottom mines and the Blagill Burnfoot mines, that lead has been profitably worked below the bed of the rivers Nent and Tyne, and in each case the depth of the deposits is restricted to a few feet. None of the veins cut through by the Nentforce level contained lead of the least importance. Many of the veins at the depth of this level were simple cracks in the rocks, in which no minerals of any kind were deposited, or chemical change of any kind effected.

Perhaps more than three-fourths of the lead produced, from the 150 feet of section alluded to above, has been found in a section of 12 feet of little limestone and 48 feet of great limestone.

North Wales.—Very few of the Flintshire lead mines go deeper than about 100 fathoms = 600 feet.

Cardiganshire.—Fron-Goch, Goginan and a few other lead mines may be 130 fathoms below the adit—which is about 30 fathoms below the surface—giving about 160 fathoms from the surface of the hills, or 960 feet as the average depth.

Isle of Man.—Lead and zinc mines:—

Great Laxey, below adit level		233 fms.	} = 1,560 feet
" adit varying from		20 to 30 "	
North Laxey	from surface	136 fms.	= 816 feet
Foxdale	"	155 "	= 930 "
East Foxdale	"	105 "	= 630 "
Ohio	"	75 "	= 450 "

MINE SURVEYING. See Dialling.

MOLASSES. There has been much discussion as to the origin of molasses. It is generally thought to be due to non-crystalline organic bodies, gums extractive, and the like. Some, however, have thought it to be produced by the presence of mineral salts in the saccharine juice. M. Asthon, in Dr. Quesneville's *Moniteur Scientifique*, attempts to show that chloride of calcium added in small quantities decreases the yield of molasses. He states, however, that if added in large quantities it prevents altogether the crystallisation of sugar, and the whole mass becomes molasses. If this is confirmed, it would appear that molasses is due to the presence of any body which will prevent the crystalline formation.

MOLYBDO-ARSENATE OF LEAD. See Achrematite.

MONAS PRODIGIOSA. A spherical bacterium which infects eatables and gives them a red colour. It is carried from place to place by insects, and its spores are conveyed by the air. When seen under a microscope with a magnifying power of 1,000 diameters it appears to consist of round bodies filled with a red substance and swimming in a red fluid.

This colouring-matter dyes cotton and linen pink, and wool blood-red. The colour cannot be washed out, but it fades in sunlight.

The colouring-matter of *monas prodigiosa* is insoluble in water or ether, but it dissolves in alcohol with a blood-red colour. The difference between this dye and aniline is shown in the following table:—

	Aniline Red, a weak solution of Fuchsine	*Colouring-matter of Monas Prodigiosa*
Hydrochloric acid .	Violet, decolorised by excess.	Pink, unaltered by excess.
Sulphuric acid . .	Violet, blue with more acid, faint yellow with large excess.	Pink, violet with excess.
Nitric acid . .	No change, with excess first dirty violet, then dull green.	Pink, dirty yellow with large excess.
Potash or ammonia .	Colour fades, is not restored on addition of acid.	Pure yellow—unaltered on heating—on addition of acid pink colour is restored.
Carbonate of potash .	Colour fades . . .	Yellow.
Carbonate of ammonium.	No change	No change.
Chloride of tin .	Violet	No change at first, but gradually bleached.

The colouring-matter may be obtained tolerably pure by slowly evaporating the alcoholic solution of *monas prodigiosa* and dissolving the deposit in petroleum, which leaves a brown tarry residue. On evaporation in petroleum the dye is obtained.

MONKEY FRUIT TREE. See Baobab.

MONOACETYLALIZARIN. $C^{14}H^6OHO.CO.CH^3O^2$, crystallises in golden yellow scales. — See Alizarin.

MONOAMIDOANTHRAQUINON. $C^{14}H^7(NH^2)O^2$. — See Alizarin.

MONOBROMANTHRAQUINON. $C^{14}H^7Br(O^2)$. — See Alizarin.

MONONITROANTHRAQUINON. $C^{14}H^7(NO^2)O^2$. — See Alizarin.

MONOSULPHOANTHRACENIC ACID. $C^{14}H^9SO^3H$. For description of these and other products of alizarin, see *Anthracen*, by Auerbach, translated by Crookes.

MORDANTS USED FOR DYEING COTTON. The mordants most generally used for dyeing cotton aniline blue are as follows:—For diphenyltannic blues, the sulpho-conjugated salt of the blue being a calcic or barytic compound, it is sufficient to mordant the cotton in a solution of tannin at 3 per cent., and to pass directly into a solution of alum neutralised with carbonate of soda, then dye directly in the aqueous solution of the blue; brighten, wring and dry. For alkaline blues, of which the sulpho-conjugated salts are generally sodic or ammonic compounds, we take likewise an aqueous solution of tannin containing 3 per cent. of the weight of the cotton; keep at a boil for a quarter of an hour, wring and dry. Then pass the cotton into a bath containing $1\frac{1}{4}$ kilograms alum, 250 grams tartar emetic, 750 grams soda crystals, and 250 grams tartaric acid. These ingredients are dissolved separately, and finally the colour is added. The bath is heated from 65° to 70°, the cotton is entered and worked while the temperature is allowed to sink. The

bath serves continuously, more mordant being added as it becomes exhausted. Heavy shades are dyed first, then mediums, and then pale shades. To dye cotton with saffranin and bright green, the cotton is first passed into a solution of bichloride or oxymuriate of tin, marking 2°, wrung, passed into a tannin bath, wrung, and then passed into the dye-beck. Cotton may also be mordanted in a solution of nitrate of urea (2 grams per litre of water) at a boil, wrung, and passed into a solution of biphosphate of lime at 5 grams per litre of water, wrung, and entered in the colour bath. In this manner almost all the aniline colours give very bright colours. —*Chemical News*, vol. xxxii. No. 816, p. 30.

MUCYLIN. A preparation so called is sold as a grease for wool. It is composed of about 20 lb. avoirdupois of fatty acids, the same quantity of potash soap, about 11 lb. of glycerine at 28°, about 150 grains of sulphate of zinc, and about 55 pints of water. The fatty acids are mixed with the glycerine, and the soap added. The mixture is diluted with 17 pints of water at 80°, in which 150 grains of sulphate of zinc have been dissolved. The water is added with constant stirring.—Dingl. *Polyt. Jour.*, ccxvi.

MUNTZ METAL. (See Brass, vol. i. pp. 469–471; also vol. iii. p. 374.) Comparatively few of those who neither make nor deal in it, are aware of the great utility of this metal in the arts. So extensively is it used that it has almost completely superseded copper for sheathing for ships, partly on account of its being cheaper to manufacture, and partly owing to the circumstance of its being better adapted for the purpose. The reason for the manufacture being less costly than that of copper, is that a large proportion of zinc is retained. It answers the purpose of sheathing for marine vessels so well because the zinc in the alloy corrodes entirely over the surface, and prevents barnacles, &c., from attaching themselves to the bottom of the ship. The composition of this metal varies considerably in proportions, but generally it consists of about 60 parts of copper to 40 parts of zinc, has a pale yellow colour and is very malleable, with a fracture somewhat granular. Sometimes a little lead is added to the alloy: it is, therefore, a kind of brass. Muntz registered his first patent in 1832, when he stated the following composition: 56 per cent. of copper, 43·25 zinc, and 0·75 lead.

The following is a brief description of the process of its manufacture:—A furnace (reverberatory) is charged with copper and zinc, which when melted, is run into a pit lined with fire-clay. A sample is then taken of the smelted alloy by means of a small iron ladle; the sample is poured into a mould so as to produce a bar, which is immediately passed through a pair of huge rollers, and thereby flattened into a sheet; if this sheet will admit of being bent double three times successively, and the fracture and appearances are satisfactory, the alloy is considered to be all right, and the other stages of its manufacture are pursued. But should the sample not admit of being bent three times, and in doing so should break into two parts, more scrap zinc is added to the alloy, which is afterwards well stirred. The desired malleability is obtained by simply adding more zinc, and when this is completed the molten metal is ladled into iron receptacles about 14 inches square and 3 inches deep, which are fixed on wheels. The ingots are afterwards heated to a red heat and rolled into sheets by means of large rollers. Unless the rolling is done while the metal is nearly at a red heat, it cracks and splits, and would, therefore, be useless for sheathing. In adding metallic zinc to the alloy while at its hottest point, dense fumes are given off, which are oxide of zinc. The metal zinc is volatilised at a much lower temperature than the fusing point of the alloy, and it is owing to this circumstance that much zinc is sometimes lost in making this metal. On the other hand, it should not be forgotten that the affinity of the two metals for each other is great.

The yellow metal sheathing, as it is sometimes called, is next pickled in dilute sulphuric acid, so as to liberate any attached particles, as well as to clean the face of the metal. In connection with the pickling trough, which is lined with sheet lead, are a pair of circular scrubbing brushes, upon which falls a stream of water. The sheet of metal, after it has been pickled long enough, is passed through these scrubbing rollers, and this imparts a kind of polish to the surface: it is then placed on a drying floor of cast iron, which is heated by a fire underneath. All that now remains to be done to render the article fit for the market is to square the sheathing by clipping off the uneven edges.

Nails are also made of this metal, and this branch of manufacture is interesting. About 10 per cent. of tin is added to the alloy to give the nails hardness. They are cast in moulds. The good nails are put into a circular box, which is caused to revolve very rapidly by machinery, and this operation cleanses the nails by rubbing one against the other within the box. They are afterwards selected by boys and girls, and packed up into bags.

MUREXAN. When *murexid* is boiled with caustic alkali till the purple colour is changed to yellow, a precipitate of *murexan* is easily obtained by adding an excess of acid.

Murexan differs from uramil in its crystalline form, in its yellow colour, and in its precipitation by acids from an alkaline solution.

The analyses of J. Brock—compared with the numbers calculated from the formula $C^4H^5N^3O^3$—were the following:—

Carbon	33·3
Hydrogen	4·5
Nitrogen	28·0
Oxygen	34·2

J. Brock, *Chemical News*, xxxii.

MURRAYIN. A glucoside found in the flowers of *Murraya exotica*. Dr. De Vrij gives its composition $C^{18}H^{22}O^{10}$. It melts at 170°, and gives with chloride of iron a bluish-green colour.—E. Hoffmann, *Deut. Chem. Ges. Ber.*, ix.

MUSA FEHII belongs to the family *Musaceæ*. It grows on the hills in the islands of Tahiti. Several species are known, the plantain and the banana especially. The young trees yield a juice—coloured, syrupy, and adhesive. It is neutral to test-paper, and exhibits, in thin layers, a red colour, in thick layers a violet colour. In well-filled closed bottles it may be kept for months without alteration, except that after a long time a violet glutinous substance separates, exactly resembling caoutchouc. The solution, separated from the caoutchouc, is miscible in all proportions with alcohol, and then shows a most intense coloration. The filtrate evaporated to dryness yields a blue powder, which, treated with alum solution, forms a dark blue lake.

The solution of this gives with cotton mordanted with alum a faint violet inclined to grey, but when mordanted with solution of tin, a very splendid violet is obtained. When iron is used a full dark brown is produced. With silk mordanted with tin, a bright grey shade is the result.—H. C. Meerenstadt: Dingl. *Polyt. Jour.*, ccxix. See the *Treasury of Botany*.

MUSCARINA. The poisonous principle of some of the fungi is so called. See Mushrooms, Poisonous.

MUSHROOMS, POISONOUS. Prof. Schiff, of Florence, has demonstrated that the non-edible mushrooms have a common poison, *muscarina*, and that its effects are counteracted either by atropine or daturine. Italian apothecaries now keep these alkaloids in the rural districts where the consumption of the non-edible fungi is apt to occur. The hint is worth taking in England, where deaths from eating unwholesome fungi are by no means unfrequent.—*Sanitary Record*.

MUST, COMPOSITION OF. A white grape known in Sicily as 'Aramont' was used for an investigation by Cossa-Pecile, and Porro, of which the results are shown in the following table:—

Date	In 1,000 parts by Weight				Grams (15·43 grains) in 1,000 c.c. (16·38 to cubic inch) of Must							
	Grapes		Berries									
	Berries	Stalks	Must	Skins and Skins	Specific Gravity	Grape Sugar	Total Acid	Bitartrate of Potash	Free Tartaric Acid	Extractive Substance	Mineral Substances	Nitrogen
July 25 . .	927	73	913	87	1·0364[1]	8·8	36·04	7·52	7·80	44·12	2·499	·908
August 4 . .	932	68	957	43	1·0382[1]	6·94	31·87	8·68	7·10	40·96	2·200	·848
August 12 . .	937	63	958	42	1·0718[2]	15·6	30·00	6·02	5·52	77·63	2·250	·607
August 22 . .	935	65	962	38	1·0929[2]	22·7	20·92	4·51	4·80	79·83	1·777	·321
September 1 . .	944	56	963	37	1·0280[2]	57·5	20·10	5·64	3·69	72·40	4·370	·238
September 10	926	74	948	52	1·0477[2]	90·2	17·77	7·87	2·80	130·40	5·160	·088
September 20	917	83	957	43	1·0638[2]	184·7	13·76	7·74	2·21	162·40	2·091	·175
September 30	927	73	960	40	1·0582[2]	119·0	9·62	6·01	1·54	130·30	1·094	·700

Cossa remarks:—'The above numbers show that the quantity of sugar, and of the extractives of the investigated must, increased till September 20, from which date they decreased; while the nitrogen increased from this date, after it had continually decreased from July 25 to September 20. The acid present showed a constant decrease.'—Biedermann's *Centralbl. für Agrikultur-Chemie*, 1875.

[1] At 17°·5 density.
[2] At 21°·2 density.
[3] At 18°·7 density.
[4] At 22° density.

N

NABO. The name given in the Philippine Islands to the fibre obtained from the *Nauclea scabis*, a variety of the plants producing gambier or terra japonica.

NAPOLIN or **NOPALIN.** A new colour recently introduced into the market. It is of uncertain composition; some samples are said to consist of Eosin, and others of a cochineal compound.

NAPHTHALINE COLOUR. M. Ballo, in the *Gazzetta Chimica Italiana*, anno v. for 1875, says that on heating naphthylamin and bromide of naphthalin, there is produced a liquid mass of a dark red by transmitted light, which, if evaporated with ether, leaves a blue powder soluble in alcohol, with a fine violet colour, which is the hydrobromate of a base precipitated by ammonia in blue flocks.

NAPHTHYLAMINE VIOLET. This colouring matter is prepared for calico printing by boiling together 456 grams of starch, 1·1 litre of water, and 118 grams of dry naphthylamine (vol. iii. p. 403), dissolved in 1·5 litre of water and 79 grams of hydrochloric acid of sp. gr. 1·12, and adding to the liquid, after standing and cooling, 13·5 grams of chlorite of potassium dissolved in 0·3 litre of water.

This colour does not appear to be the final product of a chemical process, but merely a transition stage.—Watts's *Dictionary of Chemistry*.

The printed goods are hung for three days in the oxidising room, then drawn through a soda-bath and finally through a soap-bath, whereby their grey colour is developed into a pure violet and lake.—A. Kielmayer: Dingl., *Polyt. Jour.*, cxcvi.

NAW. An iron wood of great durability much used by the natives of Ceylon.

NEFT OIL. A shale of a bituminous character: yields a mineral oil. It is chiefly derived from Hungary and the Caspian Sea. Said to give 68 per cent. of distillate, consisting of 60 per cent. of crude paraffin, and 8 per cent. of oil.

NEOGEN. A name given to an alloy resembling silver. Dingler's *Polytechnic Journal* gives the following as its composition:—

Copper	58·0 per cent.
Zinc	27·0 ,,
Nickel	12·0 ,,
Tin	2·0 ,,
Aluminium	0·5 ,,
Bismuth	0·5 ,,

These ingredients are melted and stirred together. The addition of aluminium and bismuth confers a silvery whiteness to the alloy, but it gives at the same time a peculiar appearance, and it prevents the loss of polish.

NEPHALITE. One of the igneous rocks; consists entirely of silicate and alumina. See Lava (vol. iii. p. 46).

NICKEL. (Vol. iii. p. 413.) As we have stated in the previous article, the chief source of nickel has hitherto been the *Kupfernickel* or false copper, so called on account of its colour. This ore varies in its composition, containing from 33 to 55 per cent. of nickel, and from 33 to 40 per cent. of nickel, with some cobalt, antimony, sulphur, &c.

The other nickel minerals of value are *cloanthite* or white nickel, an arsenide of nickel; *annabergite* or nickel bloom; *millerite*, sulphide of nickel, now found in Lancaster, Pa., U.S.

The less important nickel minerals are breithauptite, nickel glance, ullmanite, emerald nickel, pyromelin, grunanite, pimelite, garnierite, and noumeite.

An important source of nickel is speiss (vol. iii. p. 413). This usually occurs as a deposit formed in the pots in which roasted arsenide of cobalt, mixed with copper nickel, is fused with carbonate of potassium and quartz, for the preparation of smalt in the blue colour works. It collects below the blue glass in the form of a metallic alloy, the nickel not oxidising so easily in roasting as the cobalt.

A remarkable ore of nickel, a silicate, has been discovered in New Caledonia.

M. Jules Garnier, in an exploring expedition undertaken under the auspices of the French Government, discovered the nickel mines of New Caledonia. Although these mines have been known since 1864, attention has only recently been directed to them.

These nickel deposits are found in the serpentine and other rocks, coating them with a green coating of silicate of alumina, nickel, and magnesia. The composition of the ore is—

	1	2
Gangue	39·40	3·00
Silica	28·60	41·00
Alumina and ferric oxide	0·60	0·60
Oxide of nickel	12·00	19·00
Magnesia	11·40	16·30
Lime	traces	—
Water	7·50	20·00
	99·90	99·90

This new ore, although its green colour is very characteristic, has been confounded with carbonate of copper. It has been named GARNIERITE after its discoverer.—*Les Mondes*, February 10, 1876.

The following description by M. HEURTEAU is the best account given of this ore:—

'*Discovery of a Vein of Nickel in Mount d'Or, New Caledonia.*—At the end of the year 1874, there was discovered in New Caledonia a well-defined and regular vein of *silicate of nickel*, capable of being worked. The vein runs in a south-easterly direction from Mount d'Or along the right bank of a little river known by the name of the river Mbéa. This watercourse flows into the little bay of Plum, which is itself part of the bay of Muéa. It descends from north to south at the bottom of a little marshy valley, which is bounded on the west by the chain of the Little and the Great Mount d'Or, on the east by the Ouaghi, on the north by a chain of the spurs of the Great Mount d'Or, and on the other side is the valley of La Coulée.

'All this region is exclusively formed of serpentine rocks, spongy silex, and piles of ferruginous jaspery clay and cavernous hydroxide of iron: on the same level there exists on the side of the Little Mount d'Or a mass of chromous iron ore. There are also some porphyritic rocks with large crystals of diallage found in the *débris* covering the soil, but it is not known how these occur in the serpentine. The silicate of nickel is very abundant in the serpentine rocks and in the porphyritic rocks in the form of little veins, or in the joints of the rocks. These masses of magnesian clay coloured by nickel are very brilliant and of a beautiful emerald green when freshly broken, but rapidly discolour and fall into dust when exposed to the atmosphere.

'The structure of the vein is breccia; it is imbedded in silicate of nickel mixed with magnesian clay which has been injected into the middle of the serpentine. It is a compact, polished serpentine of a brown colour. The barren parts, which are formed of serpentine embedded in the vein, represent a little more than half the whole mass.

'About ten mètres to the north, a second vein appears, parallel to the first. It is composed of a silicious rock, the cavities of which contain silicate of nickel.

'The prolongation of these nickeliferous veins has been found at a distance of 500 mètres on the other side of the valley on the left bank of the river Mbéa. There is also found in the same place in contact with the brown serpentine dotted with diallage, a rock formed of layers of talc, and in this rock patches of carboniferous copper.

'*Résumé. Analysis and Industrial Value of the Mineral.*—From these observations, although very imperfect, it will be seen that the silicate of nickel occurs in the serpentine in a regular vein, running from east to west, that is to say, parallel to the veins of euphotide of the bay of the Sud and of the isle of Ouen. The filling-in of this vein is formed partly of serpentine and partly of greenish silicate of nickel, imbedded in the white magnesian clay. The following is the analyses of some of the specimens that were analysed at the Ecole des Mines:—

Quartzose gangue	3·00
Silica	41·00
Alumina	0·60
Protoxide of nickel	19·00
(Corresponding to metallic nickel)	14·95
Magnesia	16·30
Lime	traces
Water	20·00
	99·90

'It is, then, a hydrosilicate of nickel and of magnesia, containing nearly 15 parts in 100 of metallic nickel. Of course the specimens analysed had been chosen with care, but admitting that the mineral taken from the mine contained only 7 or 8 parts in 100, it would still be a valuable product.

¹ Nickel is now very much used. It is employed in the mixing of money and for various other purposes, more especially in surgical instruments and for the parts of certain machinery.

² The conditions of mining in the valley of Mbéa are of a very favourable description. It is easy to lay a tramway from the seat of mining to the bay of Plum, where ships of small tonnage can find a good anchorage near the land. From the bay of Plum to Nouméa, the distance by sea is about 10 miles. As regards the future of the mining for nickel, the only point to be cleared up is, what becomes of the nickeliferous vein as the mine increases in depth. It is probable that the hydrosilicate of nickel is only a product of the surface, and that at a certain distance from the outcrop it would be replaced by the arsenical sulphides that constitute the ordinary minerals of nickel. However, these arsenical sulphides are generally associated with cobalt, of which there is no trace in the minerals of New Caledonia. There are indications of copper on the line of the nickeliferous vein; it is therefore possible that at a certain depth the nickel is associated with copper. Hence the discovery of the nickel of which we are speaking. There have been many discoveries of nickel in other parts of New Caledonia, Australia, and France, but there will not be much done in working it till it has been ascertained to what depth the veins of nickel go.

³ On December 31, 1876, the mines of New Caledonia were as follows:—

		Number of Concessions	Extent of Concessions. Hectares
Concessions sought for	District of Païta	4	1,000·00
	,, Mount d'Or	7	1,223·34
	,, Kanala	16	2,680·00
Concession acquired by possession	District of Païta	4	55·66
	,, Mount d'Or	6	60·00
	,, Kanala	33	547·20
Permission to search	District of Païta	2	60·00
	,, Kanala	11	590·00
	Sundry sets	2	132·00
	Total	85	6,602·50

—*Rapport à M. le Ministre de la Marine et des Colonies sur la constitution géologique et les richesses minérales de la Nouvelle Calédonie*, par M. Emile Heurteau, Ingénieur des Mines.

The importance of the discovery of this metal in New Caledonia, is shown by the following extract from a paper published in that colony:—'Nickel has now so much importance in our colony, that we intend to give an article on it every month, so as to keep our fellow-colonists informed of the value of their produce in the markets of Europe, and, in the second place, to give really true accounts of the quantities exported, the number and value of our mines, and the kind of people we are. After doubting for a long time the reality of discoveries made near the end of 1874 at Mount d'Or, about eighteen and a half miles from Nouméa, our people at length began to explore for nickel with great zeal and activity. The presence of ore was proved at a large number of places in our island, and people began to believe that mines might be opened anywhere and everywhere, and that we were about to enter on a period of unlimited production. Fears were entertained of a deficiency of ships to take the ore away, and it was imagined that Europe and America together would hardly consume all that was going to be raised. But these dreams and exaggerations were soon over, and the present position of affairs is that the total amount exported in the course of the past fourteen months—*i.e.* from the date of the earliest extraction to the present day, is 2,000 tons. The Bon Kaine mines send away from Canala to Germany every month about 125 tons; the Bel-Air mines at Ouaillou have raised 1,200 tons, of which 160 tons were sent to London at the beginning of 1875. In April, 1876, 550 tons were shipped for Havre per the *Buffon*, and in May 450 tons by the *Newton Mondelli*. The remaining mines, all told, including the Fatma mine, have not sent away more than an aggregate of 100 tons.'

Nickel in Spain.—In the province of Malaga a mineral has been discovered in which nickel occurs in the form of a silicate, as in the ore met with in New Caledonia. The mineral contains about 9 per cent. of nickel and no cobalt.—M. Meissonnier, *Comptes Rendus*, lxxxiii. p. 39.

Nickel, Metallurgy of.—Of the metallurgy of nickel little is known, although it is difficult to see why those who have a monopoly of the ore need fear competition. Prof. C. Künzel has, however, published some interesting facts in regard to the method used in the metallurgy of nickel, from which we glean the following:—

'The preparation of metallic nickel and cobalt is sometimes conducted in the dry way, by collecting and concentrating the nickel, cobalt, and copper in an arsenical or sulphur compound (*speise*), while at the same time the iron in the ores is removed by scorification; the cobalt is afterwards fluxed with pure quartz sand, and the protoxide of cobalt precipitated, from the silicate of cobalt thus formed, by fusion with excess of carbonate of soda; the sulphur or arsenic is expelled from the *speise*, which has had the cobalt removed by roasting and heating with soda and saltpetre, and finally reduced with carbon. It is more frequently obtained in the wet way, by dissolving the nickel and cobalt ores in acids and separating the dissolved metals; but the greater part of the iron should first be removed and the nickel and cobalt concentrated before dissolving. In the dry method the first step is also to get rid of the iron in the ore or *speise*. The complete separation of iron from arsenical compounds of nickel and cobalt is not very difficult, for iron has much less affinity for arsenic than cobalt or nickel; but to separate it from the sulphides was, until recently, very difficult, if not impossible. The reason of this is that nickel and cobalt have nearly the same affinity for sulphur that iron has. This operation is now accomplished by smelting the raw ferruginous ore in a reverberatory furnace, with a mixture of two parts of fine barytes and one part quartz sand; for 1 per cent. of iron, 18 to 19 per cent. of this flux is required. A fusible ferro-silicate of barium is formed and sulphurous acid driven out. In 1870 Dr. R. WAGNER proposed to make use of the oxidising action of the Chili saltpetre for removing the iron, sulphur, and arsenic. For arsenical products this method is inferior to the one generally employed—roasting the metallic arsenides after the iron has been removed, then heating with saltpetre and soda. WAGNER's method may be employed with advantage when it is desired to smelt a nickel ore, which has been freed from iron, with a metal free from sulphur, provided it contains enough copper to prevent the resulting metal from being too infusible.

'The manufacture of nickel in the wet way varies with the material or source. The principal steps are the following:—(1) Dissolving the roasted products in hydrochloric or sulphuric acids; (2) precipitation of the iron by means of lime or carbonate of lime or soda, after oxidising, if necessary, with chlorine or chloride of lime; (3) precipitation of the copper with sulphuretted hydrogen, or alkaline sulphides; (4) precipitation of the cobalt as sesquioxide by means of chloride of lime; (5) precipitation of the nickel as hydrated oxide or carbonate with milk of lime or carbonate of soda; (6) igniting this precipitate so as to obtain anhydrous oxide of nickel, insoluble in dilute acids; (7) leaching out the excess of lime and gypsum from the ignited oxide of nickel; (8) reduction of the pure oxide of nickel by ignition with charcoal.

'In dissolving nickel ore care should be taken to prevent silica going into the nickel solution, for on neutralising the previously acid solution all the silica is precipitated in the form of silicate of nickel. Sometimes in analyses a small quantity of silicic acid runs through all the operations, and there is no simpler method of removing it entirely at the start than by adding to the neutral solution some neutral nickel salt.

'Some important improvements in the treatment of ores of nickel, so as to obtain therefrom nickel, or alloys of nickel, and in the treatment of alloys of nickel so as to obtain nickel therefrom, or to purify them from objectionable impurities, have been patented by Sir J. MASON and Mr. A. PARKES, of Birmingham. The invention consists in reducing oxidised ores of nickel by means of granulated copper or precipitated copper, or native copper in a granular state, in conjunction with fluxes and carbon, so as to obtain an alloy of nickel and copper, which alloy may be refined either by the wet way or by the method patented by Mr. PARKES in February 1876. The patentees fuse 1 ton of the finely ground oxidised nickel ore, such as that imported from New Caledonia, with from 1 cwt. to 2 cwt. of native granular copper, or with from 1 cwt. to 3 cwt. of precipitated copper, together with a flux of about 2 cwt. of fluorspar, or 1 cwt. of cryolite, and 2 cwt. of anthracite coal or other kind of carbon.

'Another part of their invention consists in a peculiar treatment of sulphide of nickel, by preference that obtained from New Caledonian ores. In order to obtain the said sulphide they fuse the ore with fluorspar and carbon, together with native or artificial sulphide of nickel, or sulphides of copper, lead, or iron. The fusing may be effected in blast-furnaces, reverberatory or other furnaces, or in crucibles or vessels heated in furnaces. The sulphide obtained by treating New Caledonian nickel ores in the way last described may be calcined, and the product dissolved in hydrochloric acid or other solvent, and the nickel separated from the solution in the usual manner. This part of the invention is especially applicable to the treatment of poor nickel ores containing up to 4 or 5 per cent. of nickel. To 1 ton of the ore they employ from 1 cwt. to 2 cwt. of fluorspar or cryolite, and sulphate of lime or sulphate of

baryta, and from 1 to 2 cwt. of anthracite coal or other kind of carbon. The fusion may be effected in blast-furnaces, reverberatory or other furnaces, with the addition of 2 cwt. of sulphide of nickel or sulphide of copper, or mixtures of these sulphides.

'They also propose to produce an alloy of nickel and copper from sulphur compounds of nickel, preferring that obtained by fusing oxidised ores with sulphur by fusing them with oxide of copper, an alloy being thereby produced composed essentially of nickel and copper. With regard to this part of the invention, they state that to 1 ton of sulphide of nickel, by preference that obtained in the way described, they add from 2 to 4 cwt. of natural or artificial oxide of copper, or compounds of the oxide, such as malachite, together with a flux composed of 1 cwt. of fluorspar, ½ cwt. of silica, ½ cwt. of cryolite, and 1 cwt. of anthracite or other kind of carbon. The alloy so obtained may be refined in the usual manner, if not sufficiently free from impurities to be used in the manufacture of German silver, or the alloy may be refined by the method patented by Mr. Parkes.

'In treating New Caledonian nickel ores or other oxidised ores of nickel, they fuse or heat to incipient fusion 1 ton of New Caledonian nickel ores, or other oxidised compounds of nickel, mixed with 2 cwt. of chloride of sodium or chloride of calcium, chloride of barium or chloride of zinc, and by grinding the semi-fused mass and treating it with water, the water being kept in a state of agitation, the greater part of the iron contained in the ore passes off with the water, principally in the form of oxide. In conducting this process it is necessary to maintain the materials in fusion or in a state of incipient fusion from one to five hours. They calcine nickel sulphurets or arseniurets to free them from sulphur or arsenic, and afterwards convert the calcined nickel compound into a soluble chloride by calcining or roasting 1 ton of the calcined sulphuret or arseniuret with 2 or 3 cwt. of chloride of sodium. They afterwards dissolve out the soluble chloride of nickel with water, or with water charged with chlorine, so long as nickel is dissolved. Or the calcined sulphuret or arseniuret of nickel may be fused with 2 cwt. or more of bisulphate of potash (sal enixum) or other substance capable of yielding sulphuric acid, and forming sulphate of nickel, which may be dissolved out with water. The nickel may be obtained from the chloride or sulphate by the ordinary methods, or it may be reduced to a metallic state by electricity or magnetic currents, first adding ammonia or muriate of ammonia to the solution.

'In refining nickel alloyed with copper and other metallic impurities, they employ atmospheric air under pressure, hydrocarbon gas, or oxygen, hydrogen, chlorine, or a mixture of oxygen and hydrogen directed through tubes or jets, and with considerable pressure upon the melted surface of the alloy. Or the gaseous current may be forced up through the melted alloy, melted in a highly-heated vessel of the kind used in converting iron into steel, and commonly called a converter. The gaseous current is passed through the melted alloy till it is considered sufficiently free from iron, sulphur, and other impurities. This is ascertained by testing from time to time; or the nickel alloy may be purified by the use of chloride of lead, chloride of zinc, chloride of copper, or chloride of barium. In this case, to 1 ton of the alloy melted in a reverberated furnace or on a cupel of bone ash, they add from 20 to 50 lb. of either of the above-named chlorides. They agitate the melted metal and incorporate the materials by rolling, rabbling, or agitating with a pole of green wood. This treatment may be repeated after skimming each time until it is ascertained that the metal or alloy is sufficiently refined, when it is tapped out into water to granulate it.'

To prepare pure nickel from the nickel of commerce, M. A. Terreil dissolves commercial nickel in 7 parts of aqua regia, evaporates almost to dryness, redissolves in water, separating the insoluble matter by filtration, precipitates the copper with metallic iron, transforms the metals into sulphates, and lastly precipitates the iron with carbonate of baryta, and crystallises the sulphate of nickel.—*Moniteur Scientifique* du Dr. Quesneville, 1876.

Nickel in the Atmosphere.—M. G. Tissandier found that particles separated by the magnet from the sediment of rain water, and from dust falling directly from the air, contained nickel. M. Tissandier believes these particles to be meteoric.—*Comptes Rendus*, lxxxiii. p. 76.

Nickel-plating.—Herr Stolba, who some time since published a process for plating iron and steel with nickel, has recently introduced the following as an improvement on his original plan:—

'To a dilute solution (5 to 10 per cent.) of as pure chloride of zinc as possible, there is added enough sulphate of nickel to colour it strongly green. This is heated to ebullition in a porcelain vessel. The surface of the metal being completely cleaned of grease, the articles are then suspended in the liquid so that they touch each other as little as may be; and the boiling is kept up for from half an hour to an hour, water being from time to time added in place of that evaporated. The nickel is pre-

cipitated in a brilliant white layer wherever the surface of the object is not greasy or rusty. The operation can be continued for several hours if desired; but the plating will not thus be rendered much thicker. After removing the objects, they are washed with water holding chalk in suspension, and carefully dried. They may afterwards be cleaned with chalk, and they take a fine yellowish-toned polish. The chloride of zinc used should contain no metal precipitable by iron. When it cannot be obtained of sufficient purity, it may be made by dissolving zinc scraps in hydrochloric acid, and allowing the solution, containing an excess of metallic zinc, to rest, in order that the metals precipitable by the zinc may separate. Filter at the end of 24 hours, and the solution is ready for use; each portion of zinc dissolved corresponds to about 2·1 parts of chloride of zinc. The sulphate of nickel should be pure, and the cold solution should not precipitate when a plate of iron is plunged in it. When during the operation the liquor becomes a pale green, owing to the precipitation of nickel, more sulphate must be added, until a dark green is regained.'

M. Ducrerin has found that nickel deposited by electricity on the magnets of compasses preserves them from oxidation. He deposited in this way a layer of nickel on several rings of one of his circular compasses, keeping two concentric circles free from the operation. This compass was put on board a vessel which went round the world. The rings covered with nickel preserved their polish, but the others were completely rusty. The magnetic power of the nickelised rings had been exerted with difficulty, no doubt on account of the magnetic property of the nickel.—*Comptes Rendus de l'Académie des Sciences*, November 15, 1875.

M. Saint-Edme has used with much advantage a simple rod of iron, coated with nickel, for lightning conductors.

The salts of nickel employed in the electro deposit of that metal are prepared from commercial nickel, which is an alloy of nickel, copper, and iron, with traces of arsenic, containing from 40 to 90 per cent. of actual nickel. M. Terreil first dissolves the crude nickel in acids, then precipitates the copper by iron, peroxidation of the iron, and conversion of the metals into sulphates, precipitation of the iron by carbonate of baryta, and crystallisation of the sulphate of nickel. The nickel is first dissolved in seven or eight times its weight of aqua regia. The solution is evaporated almost to dryness, the residue is redissolved in water, using about five times the weight of the nickel employed. A little arseniate of iron remains insoluble, and is removed by filtration. Metallic iron, preferably small nails, is introduced into the hot liquid to about the weight of the nickel employed. It is stirred from time to time to detach the copper from the iron. As soon as a piece of bright iron is no longer coated with copper when introduced into the liquid, the process is completed. The copper is then collected by sifting it under water in a sieve coarse enough to let the coppery metallic powder pass, retaining the iron. This copper, when dried, is marketable.

The filtrate now contains merely nickel and iron. The latter is peroxidised, either by a current of chlorine or by treatment with nitric acid.

Sulphuric acid at 60 B. is then added in the proportion of 2 parts to 1 of the nickel employed, and the whole is evaporated to dryness to expel nitric acid and hydrochloric acid. The dry residue is redissolved in water, a part sometimes remaining insoluble, consisting of sub-sulphate of iron. From the solution the iron is thrown down by means of artificially precipitated carbonate of baryta. This carbonate separates the iron as sesquioxide, and forms at the same time insoluble sulphate of baryta, without acting on the sulphate of nickel. The last traces of arsenic are thrown down along with sesquioxide of iron. The precipitation is effected by gradually adding a slight excess of carbonate of baryta to the liquid, slightly heated, but not so as to exceed 60° to 80° Cent. It is complete when a further addition of carbonate occasions no effervescence, and does not become covered with a pellicle of iron. Pure sulphate of nickel then remains in solution. It is separated from the precipitate by filtration, and the filtrate is evaporated till a pellicle appears on the surface, when it is set aside to crystallise.—*A New Treatment of Commercial Nickel, so as to obtain a pure Sulphate of Nickel, without the use of Sulphuretted Hydrogen*, by M. A. Terreil. *Bulletin de la Société Chimique de Paris.*

NITO. The name given to the fibre obtained from one of the species belonging to the genus *Lygodium*. The fibre is coarse, but has been employed for mats and cordage. See Textile Materials.

NITRE. *Nitrate of Sodium.*—This salt occurs native in very large quantities in South America, especially in the district of Atacama, in Peru, where it is found at from 0·6 to 1·0 mètre below the surface of the soil. The commercial name for it is *caliche (which see).*

L'Olivier states that the nitre beds are usually covered with a harder saline deposit known as *costra*. He gives their composition as follows:—

	Nitre		Costra
	1	2	
Nitrate of soda	51·50	49·05	18·00
Sulphate of soda	8·09	9·02	10·04
Chloride of sodium	22·08	28·05	33·80
Chloride of potassium	8·65	4·57	2·44
Chloride of magnesium . . .	0·43	1·25	1·62
Carbonate of lime	0·12	0·15	0·90
Silica and oxide of iron . . .	0·90	2·80	3·00
Insoluble matter	6·00	3·18	20·10

Some samples contain traces of iodide of sodium.

It is calculated that the 131 establishments in Peru could produce 780,000 tons per annum, although the actual produce has never exceeded 300,000 tons. France receives not less than 50,000 tons annually. The imports of cubic nitre into this country in 1875 and in 1876 were—

Countries	1875		1876	
	Cwt.	Value	Cwt.	Value
From Peru	2,979,876	£1,792,110	3,064,707	£1,761,450
„ Bolivia	311,064	181,912	193,562	109,657
„ Chili	23,160	12,790	43,277	22,660
„ other countries . . .	1,027	614	—	—
Total . . .	3,316,027	1,987,426	3,301,546	1,893,767

Native Nitre in Chili.—The report of the engineer—Señor VADILLA—who was sent to survey and measure off the claims applied for at the place called Cachinal de la Sierra, has been forwarded to the Minister of the Interior, and published in the Government *Gazette*, and gives a fuller account of the discoveries than has hitherto been made known. The deposits in question are three in number, situated to the south of the 25th parallel; the first at a distance of about 16 miles to the south-east of the port of Paposo; and the second and third in an extensive plain, calculated at 18 miles in length by 18 or 20 in width, running from east to west, and distant from the same port about 55 miles, in a south-east direction. Señor VADILLA examined all the land in which prospecting had taken place, a large number of the holes having been put down at different distances, in all of which beds of nitrate were discovered. Under the sandy surface a stratum is found, which is in parts sulphate of soda of tolerable purity, and in others a mass composed of sulphates and of 'caliche' (*see* p. 180) mixed with the surface sand. Under this is situated the bed of nitrate, which is from 40 to 60 inches in thickness. The deposits are considered to be of great extent, being met with in all the holes sunk, and also wherever the earth has been removed to the depth of 20 inches by the inspecting engineer. The first deposit measured gave a superficial area of 300 acres; the second, 920 acres; and the third, 2,717 acres; or a total of about 5,000 acres. To obtain a fair approximation as to the quality of caliche, samples were taken from various localities, mixed together, and analysed, the result being as follows:—

Common result of the first deposit—lye . . 51·5 per cent.
„ „ second „ . . . 20·7 „
„ „ third „ . . . 41·7 „

'These lyes,' says Señor VADILLA, 'show the pure, anhydrous nitrate of soda contained in the caliche, and obtained, not from isolated samples, but from a number taken on the field itself, and with all the care possible in such a locality. I have not assayed separately any of the samples which composed the collective one, some of which I believe would give a lye of even 80 per cent., because I consider that what is necessary to be known is, that throughout the great extent of land comprising the nitrate deposits of Cachinal de la Sierra, the average quality is such, that it may constitute a new industry for the country. Considering the result of the analysis, I regard it as satisfactory, and have no doubt whatever that the same samples assayed on the spot would show a higher lye; for when I arrived at Copiapo they contained a larger quantity of water than they did at the deposits, which would naturally diminish the lye of the nitrate, which is nitrate of soda, containing scarcely traces of potash. There can be no doubt entertained whatever of the existence of nitrate

deposits in Chili, and nitrate of good quality.' With respect to the facilities of exportation, Señor VADILLA recommends the use of the Port of Taltal in preference to that of Paposo, not only because of the difficulty of constructing a road to the latter place, but also because of the insecurity of the bay.

NITRE-EARTH, EGYPTIAN. Called in commerce *sebah*. It contains about 1·01 per cent. of nitrate of potash.

NITRO-ALIZARIN. See ALIZARIN (vol. i. p. 70). 'PERKIN obtained this compound from diacetylalizarin, $C^{14}H^6(C^2H^3O^2)O^4$, by the action of nitric acid. ROSENSTIEHL gives the following method for its preparation:—Large flasks are coated internally with alizarin paste, which is allowed to dry, and they are then filled with the fumes of hyponitrous acid. After a few minutes the flasks are rinsed out with water, and the insoluble part treated with soda. The soda salt of nitro-alizarin dissolves in pure water, but is very sparingly soluble in presence of excess of alkali. Nitro-alizarin is also obtained if we dissolve alizarin in glacial acetic acid, and add nitrate of potassa. The nitro-compound is further obtained by treating alizarin dissolved in alcohol with nitrous acid; but in both these cases the yield is unsatisfactory, as a part of the alizarin is destroyed. Free nitro-alizarin crystallises from chloroform in orange red scales with a green reflection. It is capable of sublimation, but a large portion is destroyed. The compound which it forms with metallic oxides is more permanent than the corresponding alizarin derivatives. With iron mordants it gives a dark red violet, but with aluminous mordants a fine orange-red.

'On reduction this compound yields, according to PERKIN, amido-alizarin, but according to ROSENSTIEHL it forms two colouring matters which have not been closely examined.'—*Anthracen*, by AUERBACH, translated by W. CROOKES.

NITRO-GLYCERINE possesses a very remarkable power of rendering non-explosive substances violently explosive. If, for instance, charcoal and nitrate of potassium are mixed without sulphur, they form no explosive compound within the ordinary meaning of that term; but if from 10 to 15 per cent. of nitro-glycerine are added, a local explosion, produced by a strong detonator or by a fulminating cap, will cause the inert mixture to detonate with nearly the same rapidity as the nitro-glycerine itself. Nitrate of ammonium and charcoal, with or without sulphur, form a mixture so sluggish at the ordinary temperature, that when tried in a shell along with six ounces of gunpowder, the explosion of the latter failed to set it off, or even to inflame it; yet mixed with 15 per cent. of nitro-glycerine it detonates with extraordinary violence. Sawdust, bark, resin, starch, sugar, glucose, flour, dextrine, gum, &c., mixed with any nitrate, become, if a small portion of nitro-glycerine is added, most violent detonating fulminates. Nor is this all. Substances considered as absolutely incombustible will form explosives. For instance, chloride of ammonium, mixed with nitrate of potash and nitro-glycerine, will decompose explosively with formation of chloride of potassium, and the freed hydrogen unites with the oxygen of the nitrate. Sulphates are very much more sluggish, but, if very finely divided and mixed with charcoal, they also indicate a decided reaction, although too slow to be completed in the extremely short time which an explosion occupies. Chlorate of potash mixed with nitro-glycerine detonates even without the presence of charcoal or any other combustible. The number of organic compounds soluble or even insoluble in nitro-glycerine, which can thus be brought to decompose by detonation, is almost unlimited.

This extraordinary influence which the presence of nitro-glycerine exercises on slow explosives, and even seemingly inert substances, is easily accounted for. Being a liquid, it comes in very close contact with the mixtures, and when the detonation ensues, the fine layer of nitro-glycerine which adheres to every grain is instantaneously converted into an extremely dense atmosphere of gas, having a temperature of at least 3,000° to 4,000° C. Such a bath must quicken even the slowest combustion.—Mr. ALFRED NOBEL'S Lecture at the Society of Arts' Rooms, May 21, 1875.

M. BÖTTGER has communicated to the Frankfort Physical Society a process for preparing nitro-glycerine for lecture experiments which is perfectly free from danger. A few grams of pure glycerine, free of water, is put into a test tube, which is surrounded by a freezing mixture, and containing a mixture of 1 volume of the most concentrated nitric acid (1·52 sp. gr.), and 2 volumes of the strongest sulphuric acid (1·83 sp. gr.). Then, as quickly as possible, the whole is poured into a larger quantity of cold water. The nitro-glycerine, which has formed like oil drops, sinks rapidly to the bottom, being specifically the heavier liquid. It is then washed several times by decantation with fresh water, and, lastly, with a weak solution of soda, remove the water with a few pieces of fused chloride of calcium. Then the nitro-glycerine is in such purity that it may, without danger, be kept any length of time for lecture experiments.

NITRO-GLYCERINE AND DYNAMITE. (See NITRO-GLYCERINE, vol. iii. p. 422). Under EXPLOSIVE COMPOUNDS a table is given (p. 363) showing the

relative powers of several agents which have of late years attracted attention, and these are compared with several varieties of ordinary gunpowder.

Mr. ALFRED NOBEL remarks on this table: 'These figures are conclusive, and nitro-glycerine therein appears so highly superior to all other blasting agents as to make it almost a matter of regret that it cannot be used. But there are practical conditions in mining which considerably reduce the apparent useful effect in its favour, and place dynamite almost on an equality with the liquid explosive. This cannot be explained without entering into some details, for which the importance of the matter will serve as excuse.

'To get the full benefit of a blast, there should be no air-chamber round the charge, for the expansion which it causes not only lessens the power in proportion to its dilation, but actually decreases the tension of the gas in a much greater measure. In the case of blasting-powder such air space cannot be avoided, in consequence of its influence on the quickness of combustion. But with nitro-glycerine it seems as if its liquid state would specially favour the exclusion of all empty space, and so it does when it can be poured direct into a blast-chamber. But apart from the impossibility of pouring a liquid into horizontal bore-holes, or such as incline upwards, experience has shown that there is very great danger connected with that practice under any circumstances. An almost imperceptible seam or fissure in the rock—and they are scarcely ever absent—will cause a part or the whole of the liquid charge to leak into the smallest cavities, and remain there until the miner, in drilling a new bore-hole, strikes it, or strikes the rock in its proximity, when it goes off, causing a fearful accident. Hence nitro-glycerine cannot be safely used without cartridges. These, to hold a liquid, must be strong, which makes them rigid. They cannot be introduced into a bore-hole without leaving a considerable air-chamber round the charge, particularly as bore-holes generally deviate a great deal from the circular shape. It is difficult to calculate even approximately the relative proportions of the unoccupied space and the charge, but certainly with the small-sized diameter of such bore-holes as are generally adopted for blasting with nitro-glycerine, the loss is at least equal to one-third of the whole space, so that three cubic inches of the chamber will hold on an average only two cubic inches of the explosive liquid. Dynamite has here all the advantages on its side, and it is much to be regretted that miners very frequently neglect to make use of it. Being highly plastic, the slightest pressure with a wooden rod compresses the charge in the bore-hole, so as to exclude all empty space. It is true that the small primer cartridge cannot be treated in the same manner, lest the detonator cap affixed to it should be dislodged. But it forms only the upper part, and a very small portion of the charge, and the air-chamber which surrounds it is therefore of no practical importance. The increased effect derived from this mode of applying plastic explosives is far greater than is generally believed. All nitro-glycerine preparations possess the same advantage, but none are quite so plastic as dynamite. Nearest to it is litho-fracteur. Gun-cotton, like nitro-glycerine, leaves a considerable air-chamber, owing to its rigidity, when made into cartridges.

'Practically the advantage of being able to fill up the blast-chamber in a bore-hole amounts to the same as if the specific gravity of the same explosive could be increased, so much as to make up by weight for the want of bulk. In other words, what has to be considered is not the specific gravity of the explosive itself, but that of its gaseous products at their moment of initial tension, when they strike the rock or other resisting medium.

'Since nitro-glycerine cannot with any degree of safety be used without cartridges, and since the unavoidable air-chamber represents an average of one-fourth, at the very lowest estimate, of the blast-chamber, a proportionate reduction should be made in computing its useful effect for blasting purposes. Dynamite thus rises nearly to its level, and ammonia powder becomes somewhat superior.'

Nitro-glycerine, it is well known, evaporates at almost any temperature. It has therefore been supposed that dynamite loses its power by keeping. Some experiments have therefore been made at the laboratory of the Technical Military Committee in Austria, to determine the quantity of nitro-glycerine which may thus be liberated from dynamite in several years' time. Samples of dynamite (40 to 50 grams), manufactured in 1871 and 1872, were taken, the composition of the first dynamite being: nitro-glycerine, 72·98; kieselguhr, 27·02; that of the second—nitro-glycerine, 72·63; kieselguhr, 27·37. These samples were deposited in August 1871, and in August 1872, in glasses lightly covered, in such a way that the gases could be easily liberated. They were kept at a temperature varying between 10° and 24° C., till the month of September 1876. On being then analysed anew, it was found that the first specimen had lost, in five years, 2·80 per cent. of nitro-glycerine; the second, in four years, 1·52 per cent. These results would be considerably different if the conditions of the test were altered; they demonstrate, however, that dynamite, kept in free air, may lose a part of its force. The author of these experiments, Captain HESS, of the

Austrian Engineers, proposes two means of remedying the inconvenience: 1. To employ or renew, after a determinate time of keeping, the supplies of dynamite; and 2. To adopt (among the conditions of acceptance), for the proportion of nitro-glycerine in dynamite, a minimum limit higher than at present.

NOCTILUCIN. A name given by Dr. Phipson to a peculiar organic substance which is supposed to produce the phosphorescence of fish, &c. It is said to be obtainable from decomposing fish, from the glow-worm, and other phosphorescent animals, by pressing with a pallet knife this nitrogenous substance through filtering paper. Its existence must still be regarded as problematical.

NOHLITE. A mineral obtained from Nohl, near Kongelf, Sweden, which resembles very nearly the samarskite of the Ural Mountains. Analyses make it agree with the formula $2(RO,Nb^2O^5) + 3H^2O$.—*Nordenskiold Jahrbuch für Mineralogie.*

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OATS. (Vol. iii. p. 429.) Some remarkable results have been obtained by Messrs. Lawes and Gilbert by using different manures for the growth of the same variety of oats grown for five successive years on the same land.

Manure per Acre	Dressed Corn	Straw and Chaff	Total Produce	Corn to 100 Straw	Weight per Bushel of Dressed Corn
	Bushels	Cwt.	Lb.		Lb.
No manure	10¼	10⅜	1,958	72	33¼
Mixed mineral manures . . .	24½	13⅞	2,332	70	35
Ammonium salts, 400 lb. . .	47	28¼	5,186	65	35½
Nitrate of sodium, 550 lb. . .	47½	27¼	5,110	69	35½
Ammonium salts, 400 lb. with minerals	59	41⅛	7,160	58	37
Nitrate of sodium, 550 lb. with minerals	57½	35	6,347	67	35¾

See Watts's *Dictionary of Chemistry* for an important article on the 'Chemistry of Oats.'

The total *Importation* of oats into the United Kingdom in 1875 was 12,436,858 cwt., and in 1876 it was 12,576,684 cwt.

The *Exportation* of oats, the produce of these islands, in 1875 and 1876:—

Countries	1875		1876	
	Cwt.	Value	Cwt.	Value
To France	71,123	£25,168	162,552	£66,290
" British West India Islands and British Guiana	36,308	18,258	24,357	12,399
" other countries . . .	3,750	2,388	13,040	5,904
Total	111,181	45,814	199,949	84,691

Of Foreign and Colonial produce, the *Exportation* was, in 1875, 45,861 cwt., of the value of 21,416*l.*, and in 1876, 110,221 cwt., valued at 45,926*l.*

OCCLUSION OF GASES IN COAL. See Coal, Gases from and included in, p. 210. The shutting up of gases in coals, a term re-introduced by Professor Graham to indicate the power possessed by some substances to forcibly absorb and retain gaseous bodies within the structural pores. *Occlude*, to shut up.

OENOKRINE. The name of a test paper sold in Paris for the purpose of detecting the fraudulent coloration of wines. See Wines, Adulteration of.

OENOLIN. (οἶνος, Wine.) The name given to the natural colouring matter of wine.

OILS. (Vol. iii. p. 451, &c.) The extent of the article referred to renders it necessary, in the present one, to refer to such improvements only as may have been introduced since that article was printed. These will be found principally to be the introduction in some form of the paraffin or petroleum oils.

Lubricating Oils.—Mr. Humfrey, of Chester, who has had much experience in manufacturing lubricating oils, has recently patented a method of purifying the

mineral hydrocarbons by which the addition of fatty oil is dispensed with, and a better lubricating material obtained. The viscidity of oil thus prepared is equal to the best olive oil, and, as it is not liable to be decomposed into fatty acids, it does not injuriously affect the metal surfaces, nor destroy the rubber valves and other similar rubber surfaces with which it comes in contact. Besides being free from liability to spontaneous combustion, it is stated that, for ordinary lubricating, this oil is perfect, as it forms no gum or acid, and has a lubricating power equal to sperm oil. The oil treated by this invention is also specially suited for lubricating fast-running machinery, and for all kinds of fast-running mechanism. Mr. Humphry first submits the oil to careful fractional distillation, and collects the heavy portion of the product. In the refining or chemical treatment, instead of agitating the chemicals with the oil by means of paddles, screws, or other mechanical means, he forces a large stream of compressed air through a pipe at or near the bottom of the vessel, by which he claims that very important advantages are obtained. As well as a most thorough and complete agitation, a considerable effect is produced, powerfully aiding the action of the chemicals used; at the same time, the great volume of air passing through carries off all traces of oils of low gravity and boiling points, the result being lubricating oil possessing more body and higher specific gravity and flashing point than any other mineral lubricating oil, making it specially adapted for lubricating the pistons, slide-valves, and other parts of marine, locomotive, and other steam-engines, steam-hammers, and other apparatus. The oil may be produced from coal, shale, peat, bitumen, asphaltum, petroleum, and other oil-producers as is found most economical and convenient.

The defect of lubricating oils in general is that they gum and become acid. Fatty oils, both animal and vegetable, in spite of very careful preparation, are liable to oxidation by the air, the result being the production of a gummy matter possessing more or less acidity. Besides this, there is always danger that the cotton-waste used in wiping the surfaces may, when it becomes soaked with the fatty oils, and is deposited in warm places, spontaneously ignite—a danger which is not incurred when any of the petroleum lubricating oils are used. When fatty oils are employed to lubricate parts subjected to great heat, as the pistons of high-pressure condensing engines, they exercise a deleterious effect on the boilers into which they are pumped with the feed-water. The high-pressure steam resolves the oils into fatty acids and glycerine, the former of which attack the metal surfaces with which they come in contact, and the latter assists in forming a kind of glutinous scum, or soap-suds, which is a well-known cause of priming.

Another lubricating oil has been introduced and strongly recommended by Mr. C. H. Gibbs, of New York. It is a compound of oil obtained from the feet of cattle, and of paraffin or petroleum oil. It is found that certain oleaginous secretions, or matter obtained by boiling from the joints, feet, and other parts of animals, when mixed with animal and other oils or fluid, can be used to great advantage for lubricating machinery and for other purposes. The said oleaginous matters are successfully extracted in the following manner:—A quantity of cattle feet and other parts of the animal are put into a clean caldron, with sufficient water to cover the said matter, and boiled at a temperature of about 240° Fahr., until the flesh and gristle separate from the bone, which will require about four hours. The neat's-foot oil given out by the boiling will float on the surface, and may be skimmed off if desired; the bones are then removed. At this stage of the process the matter which it is desired to mix with the oil, for lubricating or other purposes, is in a suitable condition to receive the oil to be mixed with it. Although the neat's foot is not necessary to the compound which it is desired to produce, its presence in the compound will not be injurious.

According to the patentee, when the matter is in the above condition, and with or without the neat's-foot oil, about one part equal in bulk of paraffin oil is added, which with advantage should first be deodorised, the mixture being boiled for about three quarters of an hour, or until the paraffin oil combines with or takes up the matter, but not long enough to decompose the animal matter, which is usually made into glue. After allowing the matter to stand about fifteen minutes to allow the heavy parts to settle, the liquid combination is drawn off so far as it can be done without disturbing the heavier matter. This compound of oil with the matter with which it combines, constitutes an important feature of this invention, being chiefly intended for lubricating machinery, but which may be used for other purposes. If it be desired to render the compound less fluid, to prevent it from running freely, so that it can be used for lubricating vertical slides without waste, about from one-eighth to one-sixth by measure of whale or other animal or vegetable oil is added to the compound; the best temperature at which to make such an addition is about 70° Fahr.

Paraffin is named as the oil to be used in making the said compound, because it is the cheapest, and also because it has been found to be the best. This invention,

however, is not limited to the exclusive use of paraffin, as other oils and fluids may be substituted.

Lubricating Power of Oils.—Mr. R. D. NAPIER exhibited at Manchester some apparatus for testing the lubricating power of liquids which exhibited much ingenuity. It will be readily understood that the lubricating power of any oil is determined by the load which can be readily moved over a given surface, and any apparatus must be constructed so as to measure readily the friction exerted between two surfaces. At the Philosophical Society of Glasgow Mr. NAPIER read a paper on this subject, from which we extract the following portion:—

'There are such large exceptions to the generally received law of the uniformity of friction at different velocities, that it becomes questionable whether it is quite entitled to the name of a law at all. The law referred to is stated to be that friction is independent of velocity, excepting only that there is what is called the friction of rest, which is always greater than the friction of motion—that is to say, it takes more force to cause one surface to commence to slide on another than to keep it moving; but it takes neither more nor less force to keep it sliding fast than slow. In reply to this I have to observe that the coefficient of friction (that is, the ratio of friction to pressure) frequently increases materially with the velocity, and, on the other hand, often decreases materially as the rate of sliding increases; also, that sometimes the coefficient of rest is not distinguishable from that of motion.

'By means of the machine referred to in the title of this paper, which is constructed for testing the lubricating qualities of different oils, I shall presently be able to show an example of each of two opposite effects—that is, of friction in the first place, increasing materially with the velocity, and *vice versâ*; and in the second place, of friction decreasing materially as the velocity is increased, and *vice versâ*; that with mineral oils the coefficient of friction is less at higher than at lower velocities, and that with animal and vegetable oils the reverse is the case. I have frequently observed results which could only be accounted for on the supposition that in some cases friction varied directly, and others inversely, with the velocity. In other cases it has been evident that the friction was greatest at a certain velocity, and decreased with either greater or less velocities.

'The following is an example of the first case at slow velocities:—A weight of about 10 tons being suspended from a pair of blocks, from which the chain led to a barrel 14 inches diameter, with a brake-wheel 42 inches diameter attached. There were five parts of chain in the blocks, so the strain on the chain was about 2 tons. The brake was of the differential kind, proportioned so as to be self-holding, with a given coefficient of friction, and the state of lubrication at the time I refer to was such that it required a weight on the brake handle to prevent the load from descending. Now, if the coefficient of friction were not affected by velocity, any weight on the lever that is sufficient to reduce any acquired velocity of descent must ultimately stop it, and the less the friction the more pressure it must require on the brake lever to counteract the weight of the load. Well, in the case referred to (and it was one of the greatest difficulties I experienced in satisfactorily using differential friction-brakes, and therefore was not at all an uncommon case), the weight on the brake lever was sufficient to rapidly reduce the velocity of slipping from 60 or 70 feet per second to that of a few feet per minute (accomplished in a small fraction of a second), and yet it would go on slipping for an indefinite time at the slower velocity. The process could be reversed by taking off weights, and thus increasing the velocity of slipping up to perhaps 30 or 40 feet per minute, when a sudden decrease would take place in the friction.

'I have now to speak of a case in which the friction varies rapidly with the velocity, and shall describe an experiment which it is in the power of many people to try for themselves. It is the friction of a belt slipping on a metal pulley that I refer to, or rather the converse of this, which is much more easily tried—that is to say, the friction between the belt and the pulley, when the pulley is made to revolve while the belt is stationary. A belt about 5 feet long, 7½ inches wide, and about ¼ inch thick, single ply, and to each end of which was attached a hook, was placed over an ordinary smooth and turned cast-iron pulley 18 inches diameter. To the one hook was attached a chain, and to the lower end of the chain a spring-balance capable of weighing 200 lb.; and to the other hook a piece of twine was attached for suspending definite weights from. The weight of the belt and pair of hooks was 6½ lb., giving about 3 lb. for the weight of each hook, plus the part of the belt below the axle. The weight of the chain to which the spring-balance was attached was 17 lb., and of the spring-balance itself 11 lb., so that the total strain on the spring-balance end of the strap was 3 lb. + 17 lb. + 11 lb. = 31 lb. plus the strain indicated by the spring-balance, and on the other end 3 lb. plus the weight suspended from the hook. If we call this latter strain S^1 and the former S^2, then if the pulley be made to revolve from the spring-balance or S^2 end to the other, and if we ascertain the ratio of the strain S^2 to

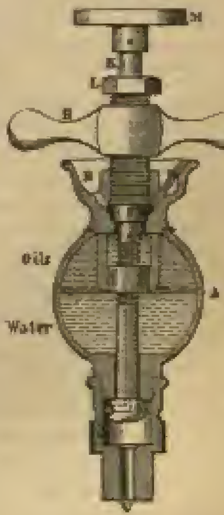
the strain S^1, we shall obtain the coefficient of friction by the following rule, applicable to the case of a flexible strap half round a pulley:—$C = {\cdot}733 \log. \frac{S^2}{S^1}$, where C is the coefficient of friction or ratio of friction to pressure.'

This extract will sufficiently serve the purpose of indicating the kind of experiment made by Mr. NAPIER. Those who are much interested in this important question must be referred to the original communication.

Lubricators with Oils.—An automatic lubricator capable of being used either by opening or closing an aperture, and thus regulating the discharge of the lubricating fluid, is represented in the annexed drawing, *fig.* 2405.

The globe, A, of this apparatus when working is filled partly with condensed greasy water, partly with the lubricating material, and the space not taken up by these two is for the condensation of steam, as will be afterwards described. To the top of this globe, A, is a cup, B, perforated at its lower sitting, and thus communicating with the globe, A. In one of these holes a tube, D, is placed for allowing the air to escape when the globe, A, is being filled. The lower part of this cup is provided with a valve seating and a screw boss, F, attached to it. An annular valve, I, can be made to rest on the forementioned valve seating, as it is fixed on the same spindle as the handle, H, and the intermediate screw shown in our figure; according as this handle is turned, so the passage between B and A will be clear or closed. Through the centre of this handle passes a spindle, K, actuated upon by the small wheel, M, and which further works through the stuffing-box, L, and through the screwed boss, F. This spindle has a passage (shown in dotted lines in the woodcut) through its centre, communicating with the chamber below the globe, and with the interior of A, by the transverse passage, E. This lower chamber has an upper and a lower valve seating, against which the double valve attached to the bottom of the forementioned spindle, K, can be alternately screwed up to by turning the wheel, M.

2405



Having thus briefly enumerated the details of construction, we pass on to the mode of filling and using this apparatus. The lubricator having been fastened on to the steam supply-pipe close to the valve-chest, the small handle, M, is screwed down, thus the steam is shut off from the lower chamber under the globe, A, by the bottom valve coming on its lower seating. The valve, I, is then raised off its seating by turning the handle, H; the lubricating material is next poured into the cup, B, when it will find its way into the globe, A, the air escaping through the tube, D. As soon as the filling is completed the handle, H, is screwed down again, and the lubricator is ready for action. In cases where this apparatus is made to work on the self-acting displacement principle, the spindle, K, is raised by means of the handle, M, thus bringing the double valve close on its upper seating. This spindle having an internal passage, the steam will be communicated to the globe, A, and coming in contact with the cold surface of the lubricating material it will be here condensed, and by its gravity will descend to the bottom of the globe, A. A very minute quantity of lubricating material will be thus displaced, which passes out into the steam-pipe through the hollow spindle (the same through which the steam enters), when it becomes mixed with the steam passing to the cylinder, thus, so to speak, greasing the steam for lubricating all the working faces. If it is, however, required to supply a quantity of lubricating material at once, it will allow this to be done, by adjusting the distance of the double valve off its seating by means of the small wheel, M.—*Iron*, February 6, 1876.

ALLEY'S lubricator and bearing feeler is an ingenious arrangement which not only tests the condition of the brass bearing, but when heating has been caused by the obstruction of the ordinary lubricator furnishes a temporary relief while giving the alarm. The mode of action is as follows:—A bell is held in an elevated position by a composition plug. If the supply of oil ceases from any cause, the bearing heats and melts the plug. The bell, thus losing its support, drops into gear with a kicker on the shaft, and rings, and continues to ring until the bearing is cooled down and the plug renewed. These plugs are formed of hard fatty matter, which melts at 130° Fahr.,

the most inflammable lubricant not taking fire until the temperature of the metal reaches 800° Fahr. As has been mentioned, the substance of the plug running into the bearings prevents the oil from increasing before steps can be taken to reduce the heat. The bearings are thus felt continuously at the right spot, and the point of alarm is fixed when the heating can be easily arrested, the feeler itself taking the first step towards that end. This is done automatically by an apparatus which is simple and not liable to get out of order, thus reducing risks from carelessness to a minimum.

Fatty Oils, Testing of.—The value of a fatty oil as a lubricant is considered to depend on the amount of acid it contains. M. Burstyn, chemist in the Naval Arsenal of Pola, has published a method for determining acidity volumetrically. The method is as follows:—A tall cylindrical vessel, provided with a ground glass stopper and having two marks on it to indicate respectively 100 cubic centimètres (6·1 cubic inches) and 200 cubic centimètres, is filled to the first mark with the oil to be tested, and to the second mark with 88 to 90 per cent. alcohol. The cylinder is then closed and well shaken. Equal quantities, other than 100 cubic centimètres, can be employed without any other change in the process. After standing two or three hours the oil settles, and the clear alcohol, which contains in solution the free acids and a little of the oil, rises to the top perfectly clear; 25 cubic centimètres of the clear alcohol is taken from the top by means of a pipette. A few drops of an alcoholic extract of turmeric is added, and the acid determined by means of a standard solution of potash, as in acetometry. The change from yellow to brownish red takes place with great sharpness when neutralisation is reached. The number of cubic centimètres of potash employed multiplied by four gives the quantity of the normal solution requisite to neutralise the free acid in 100 cubic centimètres of oil. As it is not an individual acid but a variable mixture of acids, it is not possible to calculate the percentage of acid present. These numbers, however, may be taken as degrees of acidity. For instance, an oil of three degrees of acidity is one which contains enough free acid to neutralise 3 cubic centimètres of normal alkali.

If we assume that oleic acid predominates, which in most cases is the fact, 1° of acidity corresponds to 0·28 per cent. by weight of oleic acid. The olive oil of commerce has an acidity ranging from 0°·4 to 12°. The first passes as very fine, and is called free from acid or salad oil, while the latter is known by smell and taste as strongly rancid. Oil that has 4° to 6° of acidity has been found by experiment to answer very well as a lubricator.

What relation there exists between the degree of acidity and an injurious effect upon metals is shown by the following experiments: Four shallow vessels of sheet brass, having a surface of 40 square centimètres (about 6 square inches) each at the bottom, were filled to the depth of 2 millimètres (0·78 inches) with oils of different acidity, and exposed to the air at the ordinary temperature. The vessels were soon more or less covered with green fatty salts, and the oil too acquired a green colour. Oil and vessel No. 1 were the only ones in which no change could be perceived. At the end of twelve days the vessels were cleaned with ether and weighed. The following table shows the amount of action:—

Vessel No.	1,	filled with oil of	0°·8	lost	0·03 grain
"	2,	"	4°·6	"	0·22 "
"	3,	"	7°·8	"	0·36 "
"	4,	"	8°·8	"	0·4 "

The quantity of metal destroyed in equal times and under equal conditions increases with the acidity of the oil.

This volumetric method of determining the amount of acid extracted from the oil is so simple that a person who is not a chemist can, with a little practice, perform the operation if he can obtain from a chemist the normal potash solution. There is, however, a still more simple method, invented by the same person, which depends on the fact that the more acid has been taken up by the alcohol the heavier the latter becomes. It is only necessary to be provided with two cylinders, a sufficient quantity of alcohol, and a delicate hydrometer or alcoholometer. In one cylinder is placed the pure alcohol employed, and its specific gravity is taken; in the second cylinder the oil and alcohol are shaken up together, and when they have separated the hydrometer is transferred to the supernatant alcohol and its specific gravity taken. The greater the difference in the specific gravity found, the larger is the percentage of acid in the oil tested. There must, of course, be alcohol enough above the oil to float the hydrometer without its touching the oil. The hydrometer must be very delicate, so as to read to the fourth decimal place, and the scale need only extend from 0·825 to 0·850.

Burstyn is engaged in preparing a table to show the acidity corresponding to

different readings of the hydrometer for alcohol of 88 to 90 per cent. when the acidity ranges from 0°·5 to 12°. The following table shows a few of his results:—

Oil No.	Acidity Volumetrically	Specific Gravity of Wash Alcohol	Specific Gravity of Clean Alcohol employed
I	0·8	0·8324	0·8300
II	2·2	0·8328	"
III	2·8	0·8330	"
IV	4·6	0·8336	"
V	7·8	0·8345	"
VI	8·9	0·8346	"

If some ingenious hydrometer-makers will put a suitable instrument in the market, with large bulb and short scale, we may soon expect to see this quick and simple method of testing oils introduced into practice. It will not only prove very serviceable to the owner of machinery by easily and quickly informing him whether the oil in question can be used for lubricating, but it will also be useful to dealers and producers, because it enables them to judge, without special difficulty, of the value of their wares, and to know whether the process of refining has gone far enough. It will scarcely be possible to mix adulterants with the oil so as to conceal the acid and render this test invalid, because the substance added for that purpose must be lighter than alcohol, must be soluble in alcohol as well as in oil, and free from odour—three difficult conditions to fulfil.—*American Chemist.*

Oils imported in 1875 *and* 1876.

Description of Oil		1875		1876	
		Quantities	Value	Quantities	Value
			£		£
Train oil or blubber .	Tons	14,590	469,617	15,166	443,262
Spermaceti or head-matter	"	4,469	427,884	3,218	206,369
Animal oil . . .	Cwt.	20,175	37,433	26,914	52,615
Castor oil . . .	"	45,044	90,774	79,677	133,828
Cocoanut oil . . .	"	210,159	411,565	79,431	577,480
Olive oil . . .	Tons	35,453	1,559,068	24,022	1,080,176
Palm oil . . .	Cwt.	904,562	1,506,299	79,824	1,520,300
Seed oil of all kinds .	Tons	19,061	637,131	22,760	811,421
Turpentine . . .	Cwt.	293,402	347,976	236,026	271,618
Essential or perfumed	Lb.	545,783	222,551	639,119	247,240
Unenumerated		—	126,806	—	146,504

Oil Cake.—We imported in 1875 and 1876 oil cake from the following countries:—

Countries	1875		1876	
	Tons	£	Tons	£
From Russia	9,511	102,225	14,896	151,020
" Sweden . . .	2,641	29,101	1,994	22,713
" Norway	2,465	27,023	1,605	17,079
" Denmark	1,522	15,266	750	7,857
" Germany	2,461	23,371	1,468	15,900
" France	42,692	326,226	24,555	172,960
" Italy	1,560	16,140	—	—
" Egypt	2,356	21,728	1,016	25,210
" United States of America .	112,007	1,242,985	137,164	1,322,862
" other countries . .	2,915	30,400	3,447	33,136
Total . . .	180,379	1,834,465	190,281	1,768,231

Oils, Physical Characters of.—Mr. S. Bottone has given the following table, showing the most striking physical properties of the more important oils:—

Name of Oil	Specific Gravity at 15° C., Water =1,000	Combustibility. Grams consumed per Hour in a Lamp with Wick	Freezing-point in Degrees Centigrade	Colour	Taste	Smell	Limpidity. Time (in seconds) required to trickle a given distance	Drying Power
Plum kernel	0·9127	66	− 9	Brownish yellow	Amygdalaceous	Very slight	93	Non-drying.
Rape seed	0·9128	30	− 4	Yellow	Nauseous	Nauseous	159	Non-drying.
Colza	0·9136	40	− 9·25	Yellow	Nauseous	Nauseous	162	Non-drying.
Cabbage seed	0·9139	48·5	− 8	Yellow	Nauseous	Nauseous	148	Non-drying.
White mustard	0·9142	29·6	−16·25	Light yellow	Pleasant	Very slight	167	Non-drying.
Ground nut	0·9163	?	− 3	Pale greenish yellow	Like peas	Like peas	Not tested	Non-drying.
Black mustard	0·9170	25	−17·5	Yellow	Pleasant	Very slight	141	Non-drying.
Olive	0·9176	62	− 6 [1]	Yellow	Sweet	Peculiar	195	Non-drying.
Sweet almond	0·9180	53·8	−21·5 [1]	Amber	Agreeable	None	150	Non-drying.
Horseradish seed	0·9187	43	−16·25	Yellowish brown	Pleasant	None	143	Non-drying.
Grape seed	0·9202	37	−16·25	Gold yellow	Sweet	None	99	Dries slowly
Beech-nut	0·9225	50	−17·5	Amber	Very sweet	None	158	Non-drying.
Pumpkin	0·9231	43	−15	Pale brown yellow	Sweet	None	185	Dries slowly.
Land-cress	0·9240	42	−15	Brownish yellow	Acrid	Disagreeable	103	Dries slowly.
Hazel-nut	0·9242	53·4	−10	Amber	Sweet	None	166	Non-drying
Poppy	0·9243	31	−18 [2]	Pale yellow	Flat	None	123	Drying.
Camelina	0·9252	34	−18	Yellowish	Peculiar	Peculiar	119	Drying.
Walnut	0·9260	45	−27·5	Light yellow	Flat	None	88	Drying.
Sunflower	0·9262	51·8	−16	Colourless	Sweet	None	114	Dries slowly.
Hemp seed	0·9270	46	−27·5	Dark greenish yellow	Disagreeable	Disagreeable	87	Drying.
Cotton seed	0·9306	?	− 2·5	Reddish brown	Strong	Disagreeable	Not tested	Drying.
Sesame	0·9320	?	− 5	Bright yellow	Pleasant, slightly piquant	None	Not tested	Non-drying.
Linseed	0·9347	38	−27	Dark greenish yellow	Strong	Disagreeable	88	Drying.
Wood	0·9358	44	Not noted	Green	Unpleasant	None	73	Drying.
Spindle	0·9360	61	−20	Reddish brown	Acrid	Slight	143	Non-drying.
Castor	0·9611	47	−18	Colourless	Sickly	Very slight	1,930	Dries slowly.

[1] Though these oils do not become quite solid till the point indicated is reached, yet they begin to become grainy at + 1° C.
[2] Once solidified, this oil does not liquefy until the temperature reaches − 2° C.

A glance at the table will be quite sufficient to show how little dependence is to be placed on an examination of the physical properties only, as a means of ascertaining the purity or adulteration of any sample of oil. One might think that the specific gravity would give a sufficient indication; but it must be borne in mind that several of these oils can be so altered in this respect, by freezing and separating the more solid portions, by treatment with sulphuric acid, by exposure to air and light even, that it becomes almost useless to recur to their specific gravity alone as a test. The same remark may be made with regard to their freezing-point. This is also variable according to age, treatment, &c.—*English Mechanic*, No. 502.

OILS, TESTING OF.—The detection of the adulteration of oils by their 'cohesion figures' has been ably treated by Mr. C. TOMLINSON, of King's College. He proposes to utilise the property possessed by the various oils, of forming different figures, when allowed to dry on the surface of clean, still water. In order to insure success and to obtain bold, well-defined figures it is necessary that the vase or dish containing the water should be chemically clean; that the surface of the water should also be clear and free from organic matter; that the temperature should not be less than 15° C., and that the surface of the water should be about 75 to 80 centimètres square. The time required to produce any given figure must be carefully noted, as time is an important element in the matter. These figures were minutely described in the *Philosophical Magazine* and other journals by Mr. TOMLINSON; it is only necessary to describe simply the figures produced by good olive oil and by sesame oil, which is sometimes used to adulterate the former. When a drop of olive oil is placed in the centre of a sheet of water, it slowly spreads out into the shape of a large disc, with slightly recurved edges. The cohesion of the oil, however, soon begins to get the upper hand, the disc begins to contract, the edges first testifying the return of the cohesive force: a number of little spaces begin to appear round the edges, causing them to resemble a chaplet of beads. The spaces between the beads soon open out, and the edge becomes toothed, the detached portions in some parts reuniting themselves to the main sheet of oil, enclosing polygonal spaces bounded by fine beads and covered with an excessively fine 'dew' of oil, which requires a sharp eye to detect. These changes are effected in about thirty-five seconds.

Oil of sesame, treated in the same manner, begins by forming a large well-defined sheet. Cohesive contraction, however, soon takes place, and the final figure is a central spot with distinctly marked rays, between which other smaller rayed spots appear; the whole recalling the figure of a spider's web loaded with dew. This phenomenon occupies sixty seconds in its production. Mixtures of these two oils give figures which approach more or less to one or other of the typical figures, according to which oil was in excess. As nearly every oil gives a distinct figure pattern, this method is extremely valuable. See *Philosophical Magazine* for Mr. TOMLINSON's paper on cohesion figures.

NASMYTH devised a simple plan for testing the fluidity of oils. A plate of iron 6 feet in length, having a number of longitudinal grooves of equal size, is, when placed for use, raised 1 inch at one end. An equal sample of each oil to be compared is then poured at the same time into the top of the grooves and allowed to flow. Some oils, which the first few days of the trial appear most fluid and progress the fastest, begin then to coagulate, and are passed by the better oils, some of which continue the race for eight or ten days. In one trial which was made linseed oil flowed freely during the first day, but stopped in the space of 18 inches. The best sperm flowed most freely for two days, but on the third day was passed by common sperm, which on the ninth day reached within 2 inches of the foot of the inclined plane, the other oil having stopped on the seventh day at 54½ inches.

Professor R. H. THURSTON, of the Stevens Institute of Technology, Hoboken, New Jersey, has recently invented a machine which seems to overcome the objections heretofore raised to the oil tests in use. A cast-iron standard, with two branches at the top, is bolted firmly to a square base. On the top of each branch is a stationary journal-box, in which runs a short iron shaft, moved by a pulley placed on it between the two boxes. At the outer end of the shaft there is a short projecting journal of steel or selected iron; suspended from this journal, and clasping it by means of adjustable boxes, is a hollow, round arm, hanging perpendicularly and loosely, which also has upon it a sliding weight fastened by a set-screw, the whole resembling a metronome reversed.

The pressure under which the oil is to be tested is obtained by turning a screw which is placed half way down the arm, and acts upon the lower part of a spiral spring contained inside the upper part of said arm, and bearing against the lower one of the loose boxes which clasp the trial journal. The pressure per square inch appears on a graduated scale outside the spring, and which is traversed by a finger. The machine being put in motion by a belt on the pulley, the friction at the last part of the proof

causes the perpendicular arm to swing away from the vertical position. The 'moment of friction' is indicated by a quadrant scale at the back of the swinging arm, and in which a pointer fastened on the latter moves. The 'coefficient of friction' is obtained by dividing the reading on the quadrant scale by a second set of empirical divisors laid off on the upright scale of the spring. The temperature at the test is marked by a thermometer set in brass on top of the boxes around the friction journal. In using the machine a small and determinate quantity of the oil to be tested is placed on the trial journal, and the pressure on the latter being adjusted by turning the screw below the spiral spring, the machine is started at a speed that will give the desired relative velocity of rubbing surfaces. Observations are made at short intervals and recorded, until the test is closed by rapid heating, as shown by the thermometer, and excessive increase of friction, as indicated by the movable arm swinging against the stays. Competing oils are similarly tried, and the records form a perfect means of comparison.

The relative power of resisting high temperature without decomposition is another important point which can be tested by this machine. Any lubricant can be proved, whether vegetable, animal, or mineral, tallow, or mixtures, like axle-grease. The essential feature is the combination in one machine of apparatus for making simultaneous dynamometrical and thermometrical tests of the lubricant. There is great room for the exercise of judgment by the mechanic, manufacturer, and railroad agent, in the choice of lubricators for their special purposes; and the price of the article cannot be taken as a proof of its merit for specific uses, since the best sperm oil will, in some situations, not last as long, nor perform the work as well as an oil costing only half as much, but better suited for the purpose.

The difficulty as regards machines for testing lubricants has been the impossibility of adapting them to the investigation of any oils, and not merely for comparison of a certain class, just as the various oils used for sewing machines can easily be compared by several modes which would not be suitable tests for those adapted to the rolling stock of railroads. A very simple test for factory use is to agitate two parts of the oil with one part of nitrate of mercury in a glass tube, afterwards adding a few drops of sulphuric acid and noting the changes.

OILS OBTAINED FROM BIRDS. (See OILS, vol. iii. p. 431.) The general public is not aware of the great quantity of oil obtained from birds. The fulmar (*Fulmarus Glacialis*), which breeds in immense numbers in the Hebrides Islands, and various other parts of the northern latitudes, furnishes a large proportion of the supply. The oil has a specific gravity of ·992, is of a bright red colour, penetrating odour, and in pathological qualities much resembles cod-liver oil. The penguin (*g. Aptenodytes*) of the Falkland Islands yields the largest amount. One schooner has been known to obtain 25,000 to 30,000 gallons in five weeks. As it requires 11 birds to furnish 1 gallon of oil, that quantity demanded the destruction of about 275,000. This oil is mostly sent to London, and is used for little else than dressing leather. The dusky petrel (*Puffinus obscurus*) of New Zealand is so rich in oil that on squeezing the young birds it will run pure from their mouths. The frigate-pelican (*Cachypetes aquilus*), the ostrich (*Struthio camelus*), the cassowary (*Casuarius emu*), the goat-sucker of Trinidad (*g. Caprimulgus*), and the *Steatornis caripensis* of Venezuela, all yield in the aggregate a large quantity of oil, much of which does not enter into commerce, but is consumed by the natives, who extract it by rude and wasteful processes.

OIL MILL. *Description of Oil Mill Machinery for Seeds. Rollers.*—The seed being properly screened, the first operation is to pass it between a pair of crushing rollers, by means of which the seeds are broken and reduced to a coarse meal.

A pair of these rollers is here shown in elevation by *fig.* 2406, and in plan, *fig.* 2407. The rollers are of unequal diameters, the larger, A, being usually from two to four times the diameter of the smaller, B.

The seed is supplied from the hopper, C, by means of the feed rollers, D, to which rotation is given from the spindle of the roller, A. The quantity of feed is regulated by the valve, E. Under the rollers are placed steel scrapers, F F, which are kept in contact with the rolls by the weighted levers. These clear the rollers of the crushed seed, which, from its glutinous nature, would otherwise adhere to their surfaces.

The pressure is given by a combination of a screw and compound wedge acting equally upon the two bearings of the smaller roll spindle through a strong spiral spring.

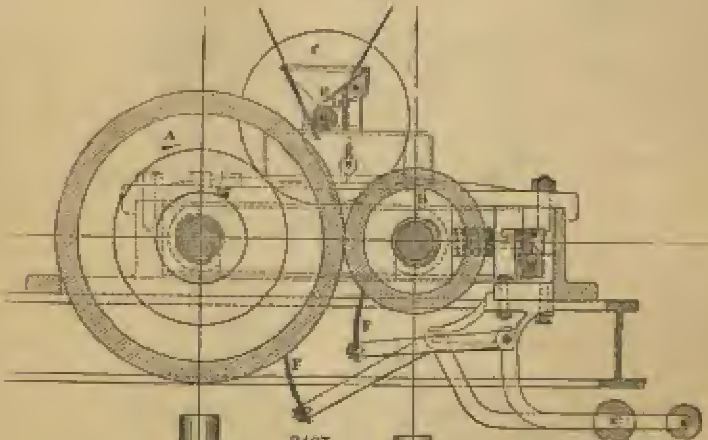
Stones.—The second operation is that of grinding the crushed seed under a pair of heavy edge-stones, as shown by *figs.* 2408 and 2409; *fig.* 2408 being an elevation partly in section, and *fig.* 2409 a plan, in which one of the stones is shown in section. The two edge stones, A A, are usually about 7½ ft. diameter, and they run upon the bedstone, B, which is surrounded by an iron kerb. The seed is kept in the track of the stones by the sweeper, D, and when sufficiently ground, the attendant, by means of the hand

lever shown, lowers the second sweeper, C, which collects it and discharges it through the opening, D, the door being withdrawn for that purpose.

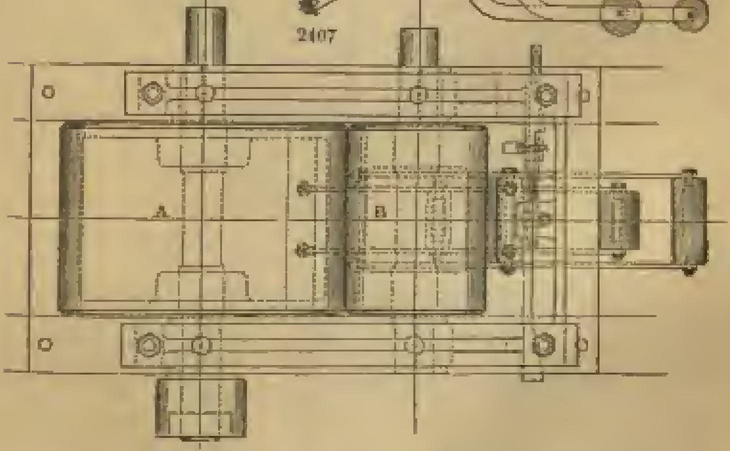
Heating Kettles.—The third operation consists in heating the ground seed in the steam-heated kettle, shown by *figs.* 2410 and 2411 ; *fig.* 2410 representing the kettle in vertical section, *fig.* 2411 in plan.

The kettle consists of a cylindrical chamber, A, surrounded by an annular space, B, into which steam is admitted by the pipe, C, which is provided with a regulating cock as shown, the condensed steam or water passing off from under the bottom of the kettle at D. The shaft, E, gives rotatory motion to the arms or stirrers, F F, which keep the seed constantly agitated, causing it to absorb the heat and preventing its adherence to the heated surface of the chamber.

2406



2407



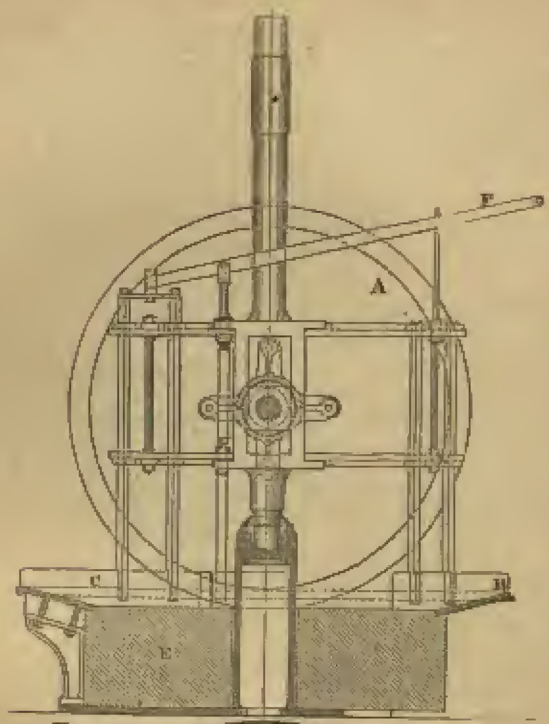
The top of the kettle has a plate-iron cover, G, with a door, H, through which it is charged. When sufficiently heated, the door, I, is opened, and the stirrers sweep the seed into the funnels, I I, through which it is filled into woollen bags suspended below.

Presses.—The concluding operation is that of expressing the oil by means of the hydraulic presses, as shown by *figs.* 2412 and 2413; *fig.* 2412 being a front elevation of a set of pumps and two presses, one of the latter shown in section, *fig.* 2413 a plan view of the same, the head of one of the presses being removed in order to show the form of the cake boxes.

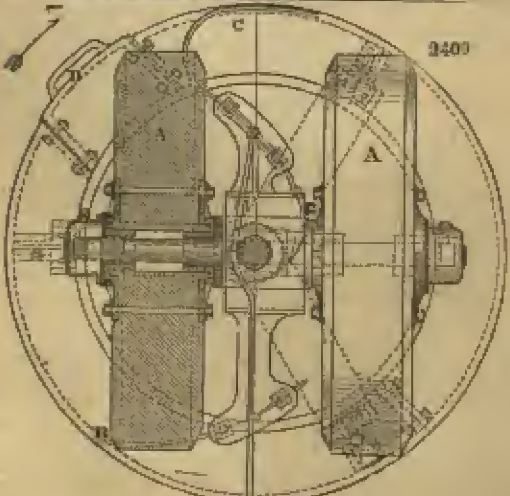
The press cylinders are supplied by two force-pumps, C and D, the plunger of the larger, C, being about six times the sectional area of the smaller, D. The larger

pump, C, is weighted to about 740 lb. per sq. in., and the smaller, D, to from 2 to 3 tons per sq. in., giving a total pressure on the rams, F, which are 12 in. diameter,

2408



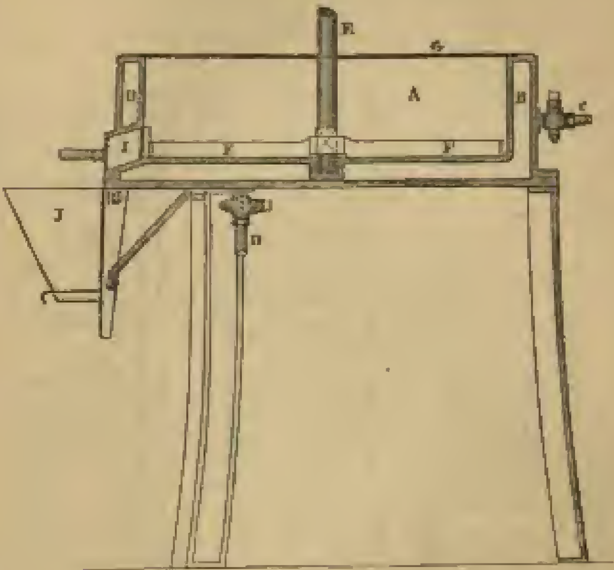
2409



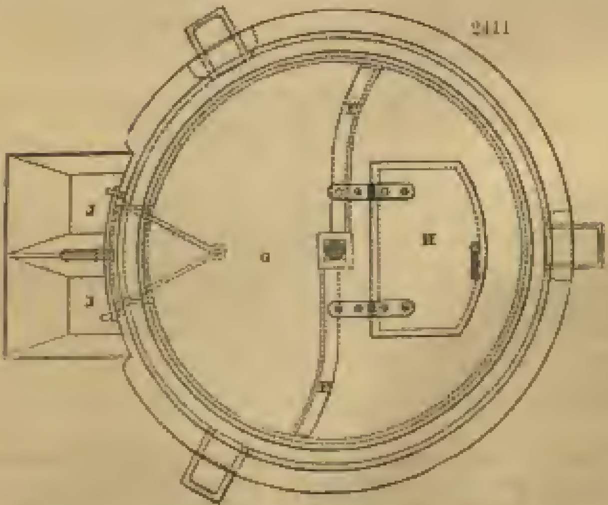
of about 200 tons. Each press is fitted with four boxes, G G G G, and in each of the spaces, H, receives one of the bags of heated seed, which has been previously placed

in a horsehair envelope. The attendant first fills one press, A, and opens the communication between the large pump, C, and the charged press, A, by means of the valves, I, which causes the ram to rise until there is a total pressure of about 40 tons exerted on the press; the safety valve of the large pump then rises. During this operation the second press, B, is being filled with the seed bags, and the communication is then

2410



2411

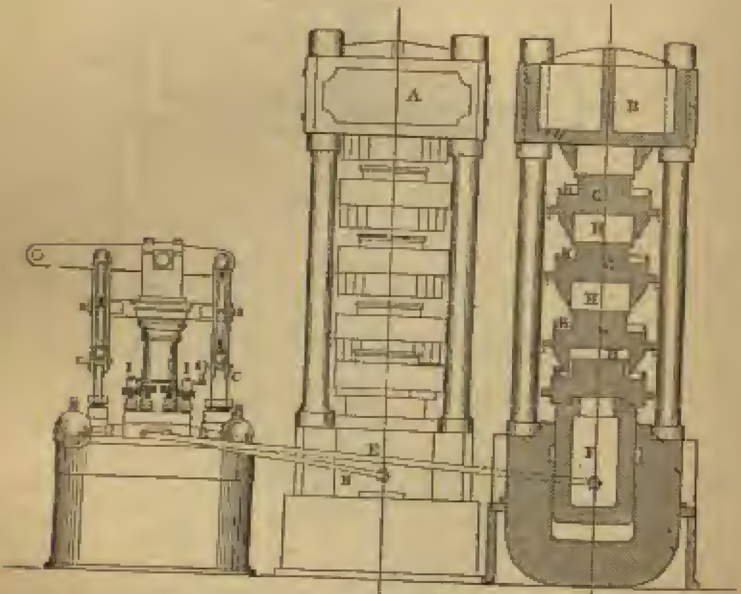


made between it and the large pump, C, and the ram of the press, B, is raised in like manner as that of A, the large pump being again relieved by the safety valve, and its communication with the presses closed. At the same time communication is opened through the valves, I, between the small pump, D, and the presses. The extreme pressure thus given, of about 300 tons, is allowed to remain on for a few minutes

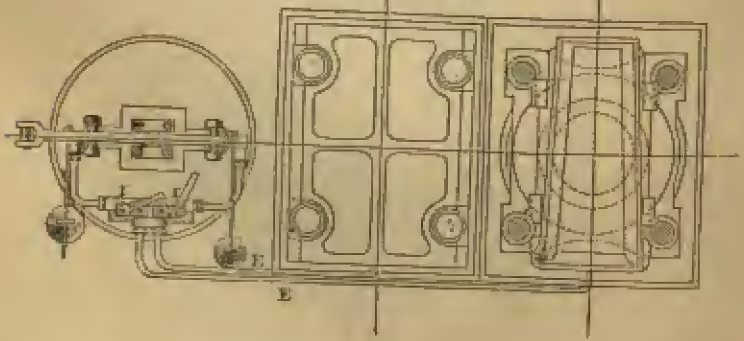
and the oil is effectually expressed. As it leaves the seed it passes through the woollen bags and the horse-hair mats, finding free exit at the edges, whence it runs into the channel, K, which passes round the upper portion of each of the boxes, G; a communication is made from one box to the other at I, so that the oil passes from the upper boxes through the lower ones and thence into a cistern usually placed below the floor, from which it is pumped at convenient times into larger tanks for storage.

The cake, after being stripped of its woollen covering, is pared at the edges and

2412



2413



placed in a rack to cool and dry, and is afterwards sold for feeding cattle, for which use its fattening properties are well known. The oil mills described are the invention of, and are obligingly described by, Messrs. E. R. and F. Turner, of Ipswich.

OIL TREE OF CHINA. (*Elæococca vernicia.*) This plant is of the family of the *Euphorbiaceæ*, and is a native of China and Cochin China. Its seeds, when submitted to strong pressure in the cold, yield about 35 per cent. of a liquid oil—colourless, inodorous, and nearly insipid. It has a sp. gr. at 15° C. of 0·9362. At −18° C. it thickens without losing its transparency or crystallising.

If, instead of ether, purified bi-sulphide of carbon is employed, the fatty matter remaining after the solvent has been evaporated off at 100° C. solidifies on cooling, forming a number of small reniform masses, which present under a lens a decided crystalline texture. This solidified fat has the same elementary composition as the liquid oil obtained by pressure, and melts at 34° C.

The oil extracted by pressure in the cold is rapidly solidified by light in the absence of air, an effect which was found to be due to the more refrangible rays of the spectrum. The oil of *Elæococca* is the most drying of all oils.—M. S. Cloëz, *Comptes Rendus*, September 13, 1875.

OLEIN and **OLEIC ACID.** See Acrylic Acids.

ONYX OF TECALI. See Alabaster.

OPAL. New South Wales. *Precious or Noble Opal.*—The precious opal of New South Wales has the milky body colour usually possessed by this mineral, and the same brilliant play of colours: the dominant colours of the scintillations are metallic green, pink, and red. Some of the best specimens form, when polished, very fine gem-stones; but here as elsewhere the valuable specimens obtained bear but a small proportion to the whole. The best have been obtained from Rocky Bridge Creek, Abercrombie River; the matrix is a fine-grained bluish-grey amygdaloidal trachyte, which is so much altered that it can be abraded by the thumb-nail; the opal has filled by infiltration certain of the vesicular cavities and crevices in this rock; it is associated with much common opal free from any play of colour.

The appearance and mode of occurrence of the opal found at Bulla Creek, in Queensland, is very different. The body colour of the Queensland opal is usually deep ultramarine blue or green, and the reflections are usually metallic green and red; the matrix is in this case a brown mottled clay porphyry, in which the opal occurs as small veins and strings.

Opal is also found in a similar clay porphyry in the Wellington District. It occurs at Bland, near Forbes; also at Cocoa, with chalcedony, agates, &c.; and at Bloomfield, near Orange.

Girasol—an opal with a red or orange tint—occurs at Wellington.

Common Opal, Semi-Opal, and Wood Opal.—Common in all the basaltic districts: Uralla, Inverell, Richmond River, Trunkey, Scone; Hunter and Castlereagh Rivers, Kiama, Lachlan River.—Professor Archibald Liversidge, *Minerals of New South Wales.*

ORCIN COLOUR. (Vol. iii. p. 461, Orcin.) See Archil, p. 81. Ten grams of orcin, ten grams of sulphuric acid, and forty grams of the reagent—nitrous acid—are, according to Liebermann, mixed. The solution must become a fine purple red. When poured into an excess of water it yields a pure red orange precipitate. The alkaline solution is purple with a scarlet fluorescence. After washing for several days it is dissolved in alcohol, filtered, and evaporated. It forms a splendid cantharides-like mass.

M. C. Liebermann (*Journal of the Chemical Society*, 1874, p. 693) shows that the action of ammonia on orcin in presence of air gives rise to two colouring matters, $C^{14}H^{12}NO^{4}$, and $C^{14}H^{12}N^{2}O^{3}$, the latter of which is produced from the former by the further action of ammonia and air. The colouring matters possess a brilliant cantharides-like lustre, and cannot be distinguished by their appearance. They form, with alkalis, fine purple solutions, that of the former inclining to red, that of the latter to blue.—*Deut. Chem. Ges. Ber.*, viii.

ORCEIN, or **ORCIN, ARTIFICIAL.** This, the tinctorial principle of orchil, is now obtained from one of the constituents of coal tar.

Vogt and Henninger, in their French patent, state that toluol, $C^{14}H^{8}$, is converted into toluolo-bisulphuric acid by the action of concentrated sulphuric acid. It is then treated with lime and again with an excess of soda at 300°, either with or without pressure.

The melted mass is dissolved in water, saturated with hydrochloric acid, the solution concentrated, and the chloride of sodium removed by crystallisation. The mother-liquor contains orcin, $C^{14}H^{8}O^{4}$, which on treatment with ammonia is readily converted into orcein.—Reimann's *Färber Zeitung.*

ORES, DRESSING OF. *Sampling Ores.*—In assaying ores for sale, or to ascertain their value, it is essential to have a *sample* properly taken. The Cornish method of sampling tinstone, described by Messrs. Roach, of Breage, is as follows:—

Assume a parcel of tinstuff at surface to be 10 tons, the mode of sampling it is—(1). It is 'spalled' to a size suitable to be stamped; (2). The pile is uniformly mixed. (3). It is divided into 'doles' or parts, ten tons into, say, ten 'doles.' (4). Any one of these ten 'doles' is selected by the captain of the mine, then weighed, allowing at the same time 10 per cent. for water contained in the stuff. (5). This one dole, or one ton, is then cut through the centre about the width of a foot. From the sides of

this cutting, a little less than a cubic foot of stuff is gently taken down by the sampler, placed in the 'sampling box,' and removed to the sampling house. (6). The stuff is broken to a uniform size—about that of a walnut—when it is distributed in the form of a circle on the 'bruising pan,' and crossed or divided into four equal parts, the two opposite parts being thrown aside. This operation is repeated four or five times, until the quantity is rendered sufficiently small to be semi-pulverised, when it is dried in a flat, low-edged pan over the fire. (7). After these various processes it is reduced to a finer state. (8). It is then further reduced as described in No. 6, viz. on the refining iron, and a small bag of this product is the 'sample.' (9). The sample is then handed to the 'sample trier,' who washes it on a 'vanning shovel,' and gets rid of most of the waste by a peculiar motion of the shovel, repeating the operation, yet still pulverising the sample, until the residue, chiefly oxide of tin, remains on the shovel. (10). This residue is now roasted in a crucible for, say, 20 to 30 minutes, according to the 'foulness,' or admixture of other metals with the oxide of tin. (11). The roasted sample is vanned, again dried over the fire, and after the application of a powerful magnet, for the purpose of extracting any magnetic particles which may happen to be present, tolerably pure oxide of tin is obtained.

The method of estimating the value of a parcel of tinstone is as follows: Quantity, say ten tons; one ounce of black tin is regarded as the equivalent of one ton, and the latter, valued at the current price, 48*l*., would represent 48*l*. per ton. Therefore,

The sum of £48	0	0	will stand for	one ounce of black tin.	
"	2	8	0	"	one dwt.	"
"	0	2	0	"	one grain	"

Now let it be assumed that the sample in question afforded 18 grains of black tin. Then 18 grains multiplied by 2*s*. per grain will give a value of 36*s*. per ton, or for the parcel, viz., 10 tons (10 × 36), the sum of 18*l*.

The tools and apparatus employed are: (1). Steel ragging sledge, 7 lb. weight, 6 × 2 × 1½ in. (2). Steel spalling hammer, 3 lb. weight, 6 in. long. (3). Sampling or bruising iron, 2½ in. square × 2½ in. thick. (4). Bucking-iron, 4 in. square, 8 lb. weight, convex face, hilt through eye, or loop, on top. (5). Refining iron, flat, with smooth face, 20 in. square. From this iron the sample is placed in the bag. (6). Bruising hammer used on refining iron, flat, 4 in. square, 3 lb. weight; hilt through eye, or loop, on top. (7). Bruising hammer used on the vanning shovel, flat, smooth surface at either end; weight 3 lb.

The method of sampling silver lead ore at the Wildberg Mines, Rhenish Prussia, may be thus described:—

The ores are divided into four classes: (1). Cobbed ore; (2). Sieve raggings; (3). Fine raggings; (4). Slimes. Each variety of ore is heaped separately during the month. As the quantity added each day cannot always be of the same metallic produce, each heap at the end of the month is thoroughly intermixed by means of shovels. The heap is then flattened and divided into quarters by two main passages made at right angles to each other, the intersection of the passages being at the

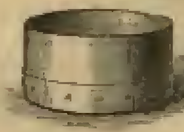
2414

centre of the heap, *fig.* 2414. Samples of No. 1, cobbed, No. 2, sieve raggings, and No. 3, fine raggings, are now taken according to the following rules. From the sides of the passage or wall of each quarter, as well as from each heap, into which the original heap is subdivided, several shovelfuls of ore are taken, and the whole placed on a plate of iron six feet square, having sides three inches high.

The sample is then well mixed together, and again divided into quarters, mixed

and subdivided if necessary in the same manner as already described, until one quarter of the pile is reduced to a weight of 25 or 30 lb. When this is done, a man turns his back against the sample, and the officers in charge mark the divisions on separate heaps 1, 2, 3, 4 (*fig.* 2414). The man then calls out which heap is to be rejected; if 'second,' then 2 and 4 are rejected and 1 and 3 constitute the sample. The sample

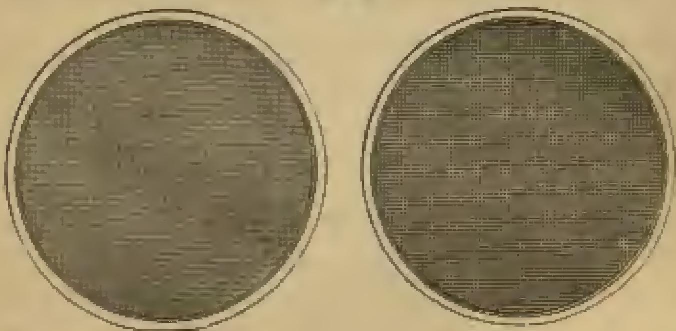
2415



2416

is then taken into the sampling-house, and, by means of a large pestle and mortar (*fig.* 2416), reduced to grains not exceeding one-fifth of an inch in diameter. After passing the reduced ore through a sieve (*fig.* 2415), it is again divided by quartering the heap in the manner already described, until the quantity is 5 or 6 lb. in weight, according to the number of samples required to be sent to the smelters.

2417



A B

This latter quantity (5 or 6 lb.) is then reduced so as to pass through a sieve (*fig.* 2417), A, perforated with holes ½ mm. diameter, or a coarser sieve, B. Should the cobbed ore, sieve, or fine raggings, be moist, through exposure to the rain or other cause, the samples may be readily dried by placing them in a copper pan over the fire. A similar method is also observed in dividing, pulverising, and taking the samples of the slimes. When, however, the sample from the latter ore is already well mixed, about 6 lb. is spread upon the bottom of the iron plate, and from several places a spoonful of ore is taken and put into a small bag. Each sample from 5 to 6 lb. in weight is then dried, pulverised, and passed through a wire or perforated ½ mm. hole-sieve. A slip of paper describing the ore is then put into each of the bags, which bags are then taken to the office, where the process of filling sample cartridges is thus carried out.

(1.) Each bag is separately emptied into a copper pan and again well stirred and mixed. (2.) The sample cartridges are now filled and both ends sealed. (3.) On each cartridge, about 7 inches long and 1 inch in diameter, is endorsed the description and estimated weight of the parcel of ore, also date of intended sale. The cartridges are simply made of foolscap paper, one sheet being sufficient for two cartridges. The paper is rolled on a piece of round wood and the outer edge glued to the cylindrical surface.

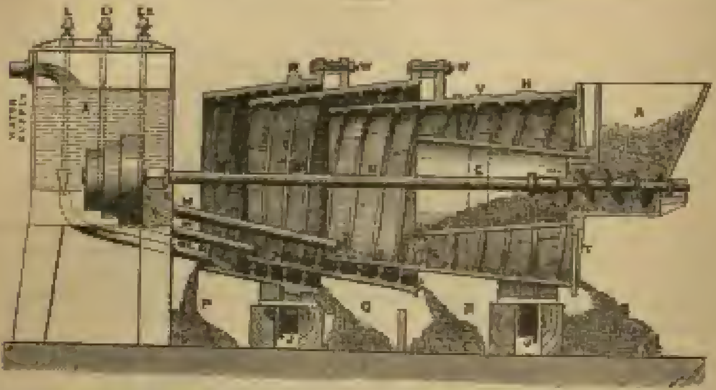
TAYLOR'S *Drum Dressing Machine.*—This apparatus, designed by Mr. HENRY E. TAYLOR, is in use at various mines under his personal management, and also at other mines conducted by Messrs. JOHN TAYLOR and SONS.

The object of the machine is to wash and separate ores and substances of different specific gravities, to size vein-stuff reduced by the crushing and stamping mill, to separate ores from their gangue, and to remove slime from fine sand before the latter is introduced to the jiggers.

The following description of the apparatus and remarks in reference thereto are by the inventor:—

'The machine consists of an arrangement of conical drums telescopically fixed (*figs.* 2418 and 2419), and mounted on friction rollers or on a horizontal axis, so as to allow of their being rotated. In the interior of these drums is a variable screw-thread,

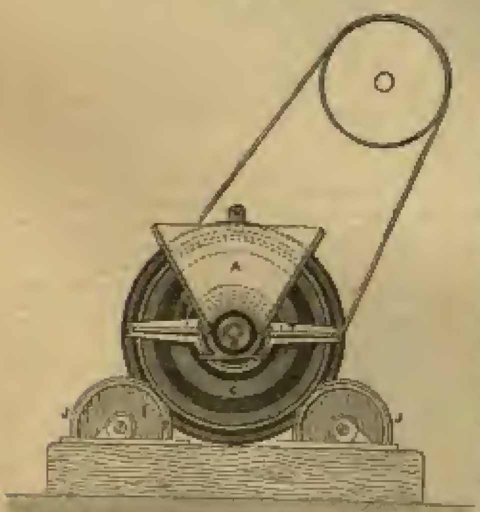
2418



the pitch and depth of the threads being greatest at the larger and gradually diminishing towards the smaller end. At the smaller or higher end of each drum is introduced a stream of water.

'A is a hopper into which the materials are thrown which require separation. B is a worm driven by a shaft and cone pulley, as shown on the drawing, for delivering a regular supply into the machine. C is a cone which traverses the material into the desired position in the first cone, D. D, D¹, D², are conical drums, and in their inner surface is formed the screw-thread, E, E, E, the number and pitch of which can be varied with the quality of the material it is proposed to treat. J, J, are rollers supporting the cones, and upon which they revolve, the drums being driven by a belt at V, or by any other suitable means. M, M¹, M², are pipes conveying the water into the interior of the machine, the supply being controlled by the plugs, L, L¹, L².

2419



'The material, in the quantity found best by experience, is first conveyed into the hopper, thence fed by the worm into the cone, which traverses it to the desired position within the drum, D. Upon the machine being rotated the tendency of the threads of the screw, E, is to carry the material up the inclined slope of the drum, but meeting with the stream of water issuing from the pipe, M, a separating action is produced, the rotary motion of the machine exposing all the particles over and over again to the action of the water; the lighter ones, being washed over the notches formed by the threads, are deposited at s, while the heavier particles or ore, gradually settling in the spaces between the threads, are carried up against the stream and deposited in the next drum, D¹. The same result is produced in this drum after the first partial separation in drum D, but in a more marked degree, the threads of the screw being of finer pitch and not so deep, and, the slope of the sides being

greater, the capacity of the spaces between the threads is less, and owing to the finer pitch of the screw, the material is left a longer time exposed to the action of the water issuing from the pipe, and so a more complete separation is obtained. The same result is produced in D^1 upon the stuff carried up to it, the separation being still more thorough, owing to the similar construction of screw-threads and slope of cone sides.

'To promote still further the separating action of the machine, the screw-threads in the lower ends of the drums are deeper than the threads at the smaller end, so that, although the material fed into the machine may fill the threads in the larger end of the cone—by reason of the rotary motion—this quantity is constantly being compelled to overflow the threads higher up, and so the water is able to overcome any large particles which might otherwise by their size, independent of their specific gravity, be carried up in the thread. The conical form of the drums is also especially designed to assist in a most important manner the action of the water by allowing the stream, which is deep, contracted, and consequently rapid, when flowing over the heaviest particles at the smaller end, to gradually spread itself out, decrease in rapidity and depth, and so give time for small grains of heavy material to settle themselves again in the threads, instead of being washed down with the lighter particles. If the machine were made cylindrical this property would be lost. The dresser can be adjusted with the greatest delicacy to suit the different wants of ore separation in a variety of ways; by altering the flow of water, the speed of the machine, and the angle which the lower portion of the cones form with the horizon. Thus the machine will be seen to be eminently adapted for the separation of ores from their gangue and coal from its impurities:—

'1. By the action of the water, washing the material over the notches of the screw-threads, by which the heaviest particles are intercepted.

'2. The rotary motion, and the variable depth and pitch of threads, continually exposing the whole of the particles to the power of water.

'3. The almost infinite means of adjustment which are at hand.

'4. The small quantity of water required, and of power necessary, with the consequent freedom from wear and tear.

'5. The extreme simplicity of the machine, reducing hand-labour to a minimum.

'Dressers 3 feet in diameter at the largest extremity of the cone have been constructed, and are in successful operation at the MINERA HALVANS DRESSING COMPANY'S works, near Wrexham. These machines are now treating successfully the jig stuff, containing only 2 per cent. of blende, and are capable of getting through 3 tons per hour. The quantity of water used in the operation is conveyed by a pipe $1\frac{1}{2}$ inch in diameter, with about 10 feet head, so that a most favourable comparison is made in this important item alone with other dressing-machines.'

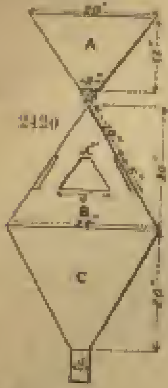
The following remarks (SAMPLING ORES IN COLORADO, by T. EGLESTON, Ph.D.) are reprinted from *Engineering*, December 15, 1876:—

'The European methods of sampling ores by hand are long and tedious, and with the high price of labour in Colorado expensive. A great many attempts have, therefore, been made to do this work mechanically, and thus avoid the labour. Of the numerous expedients which have been devised for doing this work, some have been more or less ingenious and more or less successful. The object of all of them has been to secure directly from the crusher a given part—in most cases a tenth—of a ton of ore thoroughly mixed, so as to represent the average value of the whole. There are several ingenious ways of doing this in Colorado, two of which I propose to describe; one being employed at the Lebanon Mine, under the direction of Dr. FOBLE, and the other at BENNER'S Sampling Works.

'At the LEBANON MINE COMPANY'S works the ore from the crusher is raised by an endless chain, and is charged into a bin, from the bottom of which a funnel, A (*figs.* 2420 and 2421), 12 inches high and 20 inches in diameter at the top, with an opening 2 inches in diameter at the bottom, discharges the ore over the sampler, B C. This funnel is covered with a coarse screen to keep out pieces of ore of too large a size, pieces of wood, leather, or any other material which should not pass over the sampler but which might be carried up by the chain. The sampler consists of a cone, B, the apex of which is exactly in the centre of the discharge tube of the funnel, and $2\frac{1}{2}$ inches below it. This cone is 30 inches high and 24 inches in diameter at its base. At this point another cone, C, is securely fastened to it by its base, and from the small end of the lower cone a discharge-pipe 2 inches in diameter leads to a wooden receptacle below. The upper cone has four holes at equal distances, these commencing at 10 inches from its apex. They are 1 inch wide at the top and 3 inches at the bottom, and 6 inches long. All of the ore discharged into the upper funnel falls over this upper cone, and part of it passes through these holes and falls into the receptacle, where it is collected. The size of these holes is such that the sample obtained will

be 8 per cent. of the ore. They can, however, be arranged to give a larger or smaller supply by increasing or diminishing their size. It is necessary to have a considerable

2420



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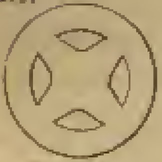
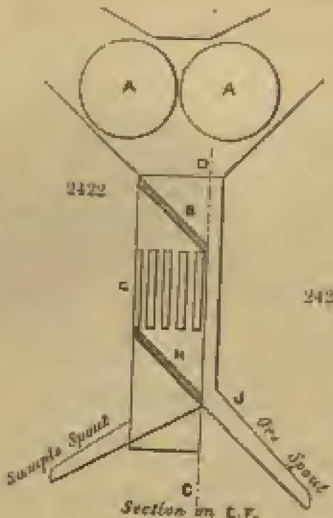


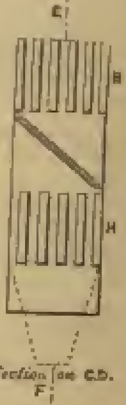
Plan of B.C.

2422



Section on E.F.

2423



Section on C.D.

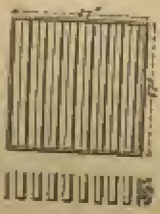
number of extra cups for the cone, as the ore falling constantly upon them wears them out rapidly, and they must be replaced. All of the ore which is discharged from the cone goes into a bin to be bagged for shipment.

'When the whole of the ore to be sampled has passed over the sampler, the first sample collected is thrown back again into the upper hopper, and this is repeated several times until it is reduced to about 40 lb. It is then passed through a sieve of

2424

2426

2425



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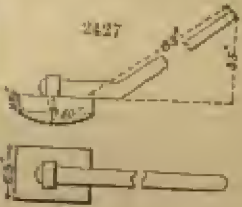

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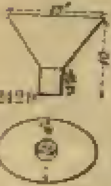

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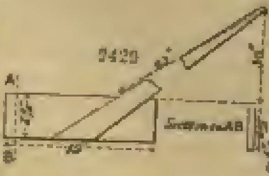

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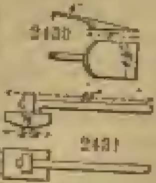


2431

forty to the inch, and the ordinary sample for assay taken of it. All the rest of the first sample is bagged to be sold or treated.

'At Brewer's Mill the sample is taken somewhat differently. The ore is raised to

two Cornish rolls, A (*figs.* 2422 and 2423), from which it is discharged into a hopper. This hopper has a trough at the bottom which is provided with a slanting shelf, B, at an angle of 50°, which is divided into nine equal parts, six of which open on to another inclined shelf, G. At the end of the shelf, B, an opening one-half times as wide as the openings in the shelf leads down to the discharging-trough, J. The shelf, G, has the same angle of inclination as the shelf, B, but is at right angles to it, and is divided into ten equal parts with five openings. The ore which passes over this shelf is discharged into the slide, J. What passes through it is discharged on to another shelf, H, at right angles to G, but with the same inclination and parallel to the shelf, B. This shelf is also divided into ten equal parts with five openings. What passes over it goes to the discharge-spout, J, and what goes through it goes to the sample-spout, I, where it is collected and the assay sample taken from it.

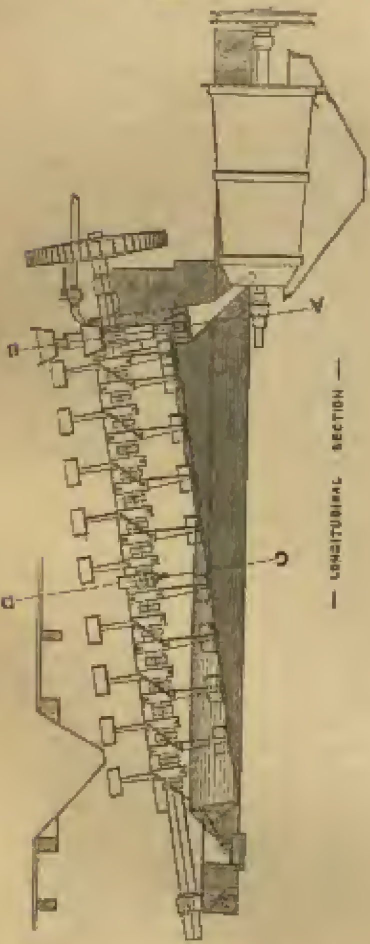
'The whole of the ore from the sampler is carefully made into a conical pile. From different parts of it with a motion towards the centre, and up and down from the bottom and diagonally across, samples are taken with a scoop (*fig.* 2424). When the pile is very much broken and has lost its shape, it is turned over and reformed, and the operation commenced again, and continued until the material collected amounts to a pailful. It is then poured, for the convenience of handling it, into an ordinary miner's gold pan, which is 16 inches in diameter at the top, 10 inches at the bottom, 3 inches high, and is then turned on to a box made of tin, 17 inches square, divided into seventeen divisions 1 inch wide (see *fig.* 2425). Eight of these divisions have bottoms and catch the ore, and nine are open and allow the ore to fall on to the floor. When the box is filled with ore it is made even on the top, the residue falling from the sides, if any, being carefully collected and put back into the pan; the box is then lifted, and what remains on the floor is returned to the ore-bin. What remains in the box is put on one side. This operation is repeated until the sample is exhausted. What has been collected in the boxes is now put through another box of the same kind, which is 12 inches square, 3 inches high, and has twenty-three divisions, ten of which catch the ore. What remains in the box is put on one side as before, and the rest returned to the ore-bin. The sample collected is thrown on to a sieve, which has a wooden frame 16 inches by 12 inches, and 4½ inches high. This sieve is three to the inch. What will not pass the sieve is broken on the cast-iron plate, which is 60 inches square and 1 inch thick, with a grinder, to which a backward and forward motion is given. This grinder is cast flat, but is rapidly worn, so as to have a rounded surface, as shown in *fig.* 2427. The ground ore is then returned to the box shown by *fig.* 2426, and put through two or three times, depending on the size of the sample. It will then have been reduced to 3 lb. or 4 lb. What has remained in the box is poured on to a sieve, which has a tin frame, and is 12 inches in diameter, 2½ inches high, and has fourteen meshes to the inch. What does not go through is again ground, and is added to what has already passed. It is then thoroughly mixed in the pan (*fig.* 2424) with a suitable shovel, and again put through the box shown by *fig.* 2426. The sample will now be reduced to a little less than a pint. It is emptied through the funnel (*fig.* 2428) into a can, and goes to the assay office. At the assay office it is still further reduced in bulk. The assay office sampler is like those shown by *figs.* 2422 and 2423, but it is much smaller. It is 7 inches by 6 inches and ½ inch high, and has six divisions to catch the ore, and seven open ones. The sample is put through these until it is reduced one-half. It is then ground with a small grinder (*fig.* 2431) on a cast-iron plate 20 inches by 18 inches and 1 inch thick, which is surrounded by a wooden frame which projects about 1 inch above the top, and fits it so loosely that it can be easily removed. The ground ore is now put through a seventy to the inch sieve, and is then ready for the ordinary assay. This method of sampling appears complicated from the description. It is, however, very simple, and the sample is very quickly taken. The method is very easily learned by any workman who has intelligence enough to work around a sampling mill. The apparatus required is very inexpensive, and the sample is much more likely to represent the real value of the ore than samples which are taken in the usual way.

Continuous Ore Washer.—The apparatus illustrated is in operation at the Burra Burra Mines, South Australia. It is employed at that place for the purpose of disintegrating a semi-indurated clay, liberating therefrom small nodules and large grains of blue carbonate of copper, so as to prepare the latter ore for the jiggers. The longitudinal section, *fig.* 2432, shows the apparatus to consist of an inlet hopper, an inclined semicircular trough, a revolving shaft, carrying a series of paddles specially arranged on the shaft, discharging scoops, and a trommel for dividing the stuff previous to its entrance into jiggers, the latter apparatus not being shown. The action of the apparatus is as follows:—Stuff is introduced to the lower end of the

trough through the hopper, the stuff is carried by means of the paddles to the head of the trough against the flow of the water until it is delivered into the scoop receptacle, when it is lifted over the edge of the trough and falls into the trommel. Water is introduced to the trough by means of a cock, as shown.

Fig. 2433 shows a section of the trough through the line A B, and *fig.* 2434 shows a

2432



2433

2434

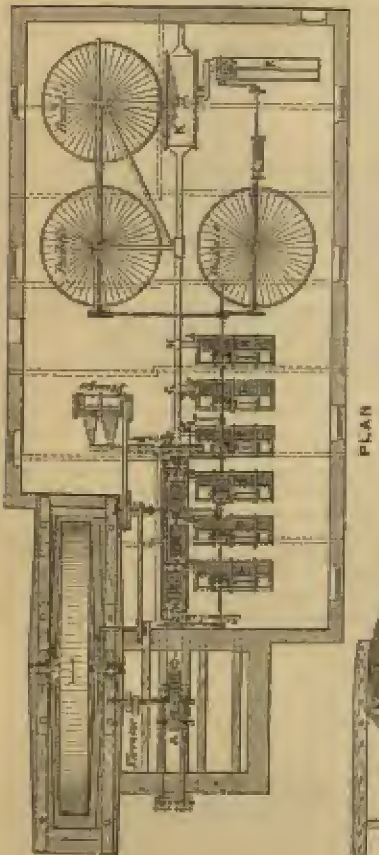
second section through the line C D. The shaft and paddles revolve about 12 times per minute. The length of the trough is 14 ft., width across the top 3 ft. 6 in. The scrapers are set at an angle of 45° to the line of the circumferential movement.

GREEN'S *Self-Acting Mineral Dressing Machines.*—The following description will convey a correct idea of the principles involved in GREEN'S dressing machines. The accompanying engravings show, *fig.* 2435 a plan, and *fig.* 2436 an elevation of the self-acting dressing floors as usually arranged for work.

A, *fig.* 2435, is a crushing mill, with rollers of a size suited to the nature or daily quantity of stuff to be treated—generally about 28 in. diameter by about 16 in. wide, into which the stuff spalled, or broken down by a stonebreaker, to about 2½ in. cube is put. This crusher may be driven by an ordinary water-wheel,

as shown in *fig.* 2435, or by a steam engine or other suitable motor; whilst all the dressing machines are driven, by preference, by a separate motive power.

2435



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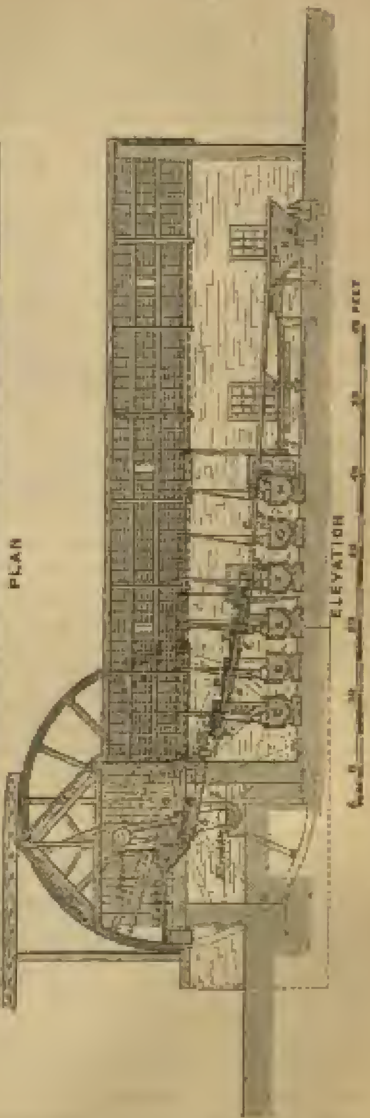
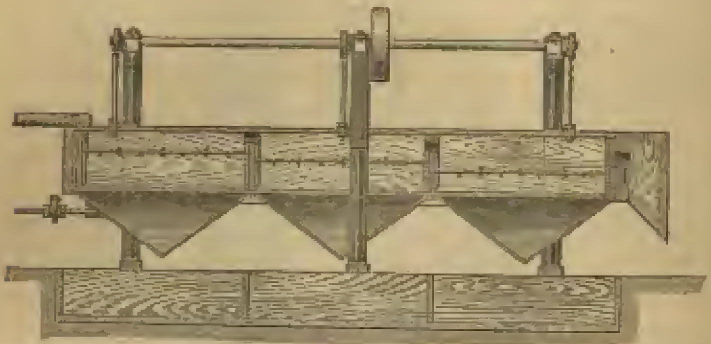


The crushing mill is usually—*i.e.* where the nature of the ground whereon the floors are erected admits—placed at an altitude above the dressing machines, so as to ensure the crushed and classified ore stuff being carried, partly by its own gravitation but principally by the force of the water current, into each of the machines provided for its separate treatment, according to the grade of its classification. Thus, the crushed ores should be plentifully supplied with water, which is not only the

medium whereby the separation of their constituents is effected, but also serves as the vehicle for their conveyance from one apparatus to another.

B is a revolving trommel, preferably made in the form of a cylinder, the outer surface of which is composed of perforated iron plate, or of metal netting, or other suitable material. A perforated pipe, of a length corresponding with the length of the net-work or perforated surface, is placed within the classifier or riddle, from which a spray of clean water is played upon the ore stuff, to wash through the perforated sides all the slimes and particles which are finer than the holes. The size of perforation is determined by the nature of the stuff to be treated. As a general rule, the richer the stuff is in mineral, the larger the perforation, and vice versâ.

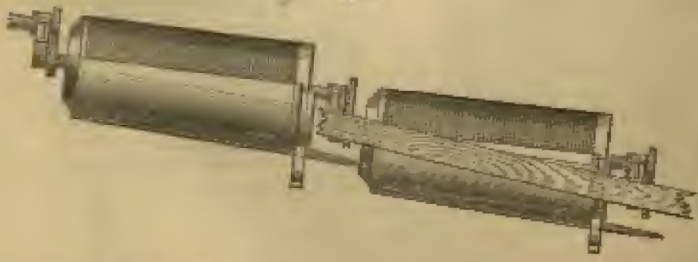
2437



This trommel, B, receives the crushed ore stuff from the trough, a, situated by preference immediately under the rollers. The ore stuff delivered into this trommel which has been insufficiently crushed is passed into an elevator, *fig.* 2435, through a shoot, *b*, which re-delivers the stuff into the crushing mill, while all that passes through the perforations of the trommel, B, is delivered into a trough, *b*, which conveys it on to the slime cone. The trommels enlarged are shown, *fig.* 2438.

The slime cone is an apparatus introduced specially for extracting the dead slimes from the coarser or granular portions of the crushed stuff, which is delivered into it from a shoot, duct, or launder, leading from the first trommel, B. It is made of either wood or iron, and preferentially of an inverted conical or pyramidal form, and is situated between the first and second revolving trommels, B and C, whence it discharges all the stuff that passes through it, beneath into a duct or launder leading to

2438



the trommel, C, whilst the extracted slimes, overflowing at the top, are conveyed by a separate launder to the water-current classifiers, F, G, H, I, K, *fig.* 2436.

C, D, E, are three trommels, similar to B. Each of these trommels is covered with perforated iron plate or netting, of a suitable sized perforation to suit the first trommel, B, the perforation or mesh of each one being finer than the one next before it, so that B, the first, has the coarsest perforations, and E, the fourth and last one shown on the drawing, the finest perforations. More or fewer of these trommels may be used, according to the nature of the stuff to be treated, and the quantity to be operated upon in a given time.

The ore stuff which has passed through the perforations of the first trommel, and

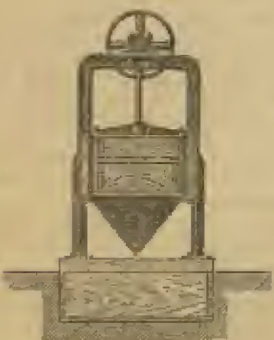
has been delivered into the trough, *b*, is thence led into the slime cone, where it is operated upon as described above, and thence into the classifier, *c*, and from it into the classifier, D, and so into E, and similarly through any number of classifiers; what passes through the sides of any one classifier being led by the troughs, *c*, *d*, *e*, into the next beyond of the series. *Fig.* 2437 is an enlarged view of troughs.

The revolving trommels may be rotated in any suitable manner. It has been usual to make the lowest trommel rotate by means of a bevel wheel on its lower trunnion, actuated by a bevel pinion on a transverse shaft, driven by a belt and pulley from the main driving shaft.

Water may also be discharged into the troughs, if necessary, to assist in carrying forward the ore stuff, and the trommels may be fitted with internal flanges to retard the progress of the stuff through them, and thus facilitate the thorough separation of the slimes from the granulated portions, and the various granulated sizes from each other. Thus, all that passes through the perforated plate of one trommel is discharged into the next in succession, while a sized product is discharged at the end of each trommel into iron troughs or shoots, *c*, *d*, and *e*, which convey it into a suitable jigging machine.

The jigging machines are represented in the drawings at C, D, E, F, G, H, *fig.* 2436. Out of the trough surrounding the last of the trommels, all the slimes and finer particles are discharged into a launder or duct. This carries them to be treated apart from the 'roughs' or larger particles in F, G, H, I, and K, which are what are known as water

2439



2440

current or saddleback classifiers and feeders, made by preference with inclined sides, meeting in an inverted pyramidal form at the bottom. (*Figs.* 2439 and 2440 are enlarged views.) A current of water, with the slimes, &c., delivered by the last revolving trommel, flows into a saddleback classifier at one end, deposits its suspended matter, and flows off at the other end into a second larger classifier, and similarly onwards to the others.

These classifiers are of graduated sizes, the first in order, E, being the smallest; and the current flows through them at different velocities, so that in the first and smallest, the current being the strongest, the largest particles are deposited, the smaller ones in the next, and so on. The smaller classifiers are provided with water pipes, attached at the bottom, and arranged so as to deliver a spray of clean water, acting upon the slimes in such a manner as to permit only of the larger particles precipitating, whilst the finer are carried forward to the last and largest classifier, where the current is very slow, and almost stagnant. No pipes for clean water are attached here, consequently all the ore worth saving will be deposited in this, the classifier being made sufficiently large to ensure this result.

The classified stuff from F, G, H, is, or may be delivered by the troughs, *f*, *g*, *h*, into the jiggers, F, G, H, and the stuff from I, K, through troughs, *i*, *k*, into either buddles or trunks, as shown in *fig.* 2436. The jiggers, C, D, E, F, G, H, which receive the stuff delivered by the classifiers as explained above, are constructed as follows:—

The jigger comprises a horizontal hutch, made of wood or iron, which is divided into two, three, four, or more compartments, by transverse ends and partitions. A vertical partition extends along the upper part of the compartments, and on one side

thereof are a set of plungers or pistons, to produce the jigging motion of the water, whilst a series of sieves are placed on the other side. The sieves are placed in the successive compartments, each at a slightly lower level than the one before it. On top of the partitions there are fixed a number of standards, to carry a longitudinal shaft, on which eccentrics are fixed, which being connected by rods to the plungers or pistons, operate such plungers, and put the water in motion; but other mechanical means may be used for producing the action of the plungers. The separation of the materials in the jiggers is effected by the jigging action of the water with which the hutch is filled, and which is made to work up and down through the sieves on the other side of the jiggers, by the plungers. A layer of ore is deposited in the sieves, which has the effect of allowing particles of the same specific gravity as itself to pass through it and the sieve, while it keeps back any particles of less specific gravity, which last are gradually washed over the end from one compartment into the next lower one, through openings between the compartments, the light waste from the last compartment finally passing away. A suitable appliance for regulating the stroke of each plunger is attached.

The granular heterogeneous stuff separated by the jiggers, and known as 'raggings,' may be subjected to a series of stamps of any kind, and the pulverised material from the stamps returned to one of the trommels, say the next to the last or lowest. Buddles, or other efficient slime machines, may be attached to the larger classifiers, and the stuff flowing in a perfectly even current from the bottom of each classifier on to each separate buddle, makes them quite self-acting, and very effective. All the labour required is to raise the deposited ore out of the jigger receiving box, and off the beds of buddles, to make room for other deposits.

The finest, or dead slimes, are worked by an ordinary paddle trunk, or other slime washer. The whole apparatus is complete and continuous, and worked without labour, each distinct sized product having an apparatus suited in speed and action for its treatment. The crushing mill, and first classifier, B, are in some cases arranged at a lower level, and the crushed stuff from them is then conveyed to the next trommel by any convenient elevator. It may also in some cases be more convenient to arrange some of the trommels at right angles to the others. The precise details above given may in many cases be readily varied to suit local circumstances, without departing from the general arrangements now described. What is claimed as the leading features of the arrangement are as follows:—

1. The combination of the crushing mill, slime cone, revolving trommels and saddleback classifiers, jigging machines, slime washers, and buddles, arranged and operated substantially as described.

2. The combination of a series of revolving trommels, with meshes or perforations of different and graduated sizes, and water current or saddleback classifiers of different sizes, so that the material may be separately treated in accordance with the classification, substantially as and for the purpose described.

3. The combination of revolving trommels with the jiggers, arranged so that each trommel will deliver to a separate jigger a sized product.

4. The combination with classifiers, or some of them, of a pipe to admit a stream or spray of water to carry off the slimes.

5. The arrangement of the apparatus, consisting of crushing mill, ducts, or troughs, classifiers and jiggers, so situated with reference to each other that the materials treated may be conveyed from stage to stage by streams of water, and with the least possible handling or manual labour.

ORES, IMPORTED. *An Account of the Quantities and Value of Ore and Regulus imported into the United Kingdom in the Year 1876, distinguishing the Ports into which imported:—*

Ports into which imported	Copper Ore		Copper Regulus		Gold Ore		Iron Ore (including Chrome)		Lead Ore	
	Quantities	Value	Quantities	Value	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£
London . .	1,477	13,066	175	7,001	30	730	1,455	3,526	1,671	12,340
Liverpool . .	10,396	182,710	9,886	600,324	14	36,600	38,963	30,358	1,907	35,357
Barrow . .	—	—	—	—	—	—	660	990	—	—
Bristol . .	104	1,094	65	3,160	—	—	—	—	1,833	23,000
Cardiff . .	—	—	1,323	63,149	—	—	187,450	198,939	—	—
Chester . .	—	—	—	—	—	—	3,905	2,064	—	—
Exeter . .	—	—	—	—	—	—	—	—	—	—
Fleetwood . .	—	—	—	—	—	—	6,301	6,403	—	—
Fowey . .	2	40	—	—	—	—	—	—	60	320
Gloucester . .	—	—	—	—	—	—	50	100	—	—

Ports into which imported	Copper Ore		Copper Regulus		Gold Ore		Iron Ore (including Chrome)		Lead Ore	
	Quantities	Value	Quantities	Value	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	Tons	£	Tons	£	Tons	£
Grimsby . .	—	—	—	—	—	—	47	105	—	—
Hartlepool . .	—	—	—	—	—	—	2,306	5,110	—	—
Hull . . .	137	1,677	42	2,470	—	—	82,763	44,938	—	—
Ipswich . .	—	—	—	—	—	—	20	60	—	—
Llanelly . .	1,010	12,100	—	—	—	—	1,004	1,710	5,797	67,045
Maldon . .	—	—	—	—	—	—	40	229	—	—
Middlesborough .	—	—	—	—	—	—	20,232	50,117	—	—
Newcastle . .	48	960	2,453	71,520	—	—	44,209	60,238	61	1,013
Newport . .	—	—	—	—	—	—	149,669	157,638	—	—
Shields, North .	—	—	—	—	—	—	8,099	15,967	—	—
" South .	—	—	1,042	31,273	—	—	32,706	14,087	—	—
Southampton .	2,777	53,860	—	—	—	—	11	37	—	—
Stockton . .	—	—	—	—	—	—	260	350	—	—
Sunderland .	—	—	—	—	—	—	13,849	16,857	—	—
Swansea . .	54,013	676,849	12,163	469,607	—	—	51,035	66,574	1,737	9,764
Wisbeach . .	—	—	—	—	—	—	80	104	—	—
Workington .	—	—	—	—	—	—	3,391	4,010	—	—
Yarmouth . .	—	—	—	—	—	—	20	15	—	—
Arbroath . .	—	—	—	—	—	—	26	102	—	—
Ardrossan . .	—	—	—	—	—	—	14,320	53,961	—	—
Ayr . . .	—	—	—	—	—	—	662	912	—	—
Borrowstounness .	—	—	—	—	—	—	725	380	—	—
Dundee . .	—	—	—	—	—	—	178	1,168	—	—
Glasgow . .	10	72	—	—	—	—	10,354	37,448	—	—
Grangemouth .	—	—	—	—	—	—	65	206	—	—
Greenock . .	—	—	—	—	—	—	712	854	—	—
Kirkcaldy . .	—	—	—	—	—	—	61	65	—	—
Leith . . .	—	—	—	—	—	—	880	1,672	—	—
Montrose . .	—	—	—	—	—	—	150	1,000	—	—
Troon . . .	—	—	—	—	—	—	63,210	47,720	—	—
Total .	74,879	808,006	27,878	1,026,214	80	27,300	673,334	702,510	12,832	176,167

An Account of the Quantities and Value of Ore and Regulus imported—continued.

Ports into which imported	Manganese		Pyrites of Iron or Copper and Sulphur Ore		Silver Ore	Tin Ore		Zinc Ore		Ore Unenumerated	
	Quantities	Value	Quantities	Value	Value	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	£	Tons	£	Tons	£	Tons	£
London . .	2,051	10,800	38,088	86,300	19,100	103	4,204	9	50	5,440	148,381
Liverpool . .	4,066	20,841	109,044	300,319	140,800	229	8,022	123	649	149	4,018
Barrow . .	—	—	146	451	—	—	—	—	—	—	—
Beaumaris . .	—	—	1,007	2,073	—	—	—	—	—	—	—
Berwick . .	—	—	2,603	4,825	—	—	—	—	—	—	—
Bridgewater .	—	—	618	1,598	—	—	—	—	—	—	—
Bristol . .	1	4	9,064	24,078	300	—	—	—	—	2	150
Cardiff . .	—	—	16,603	82,896	—	—	—	—	—	987	3,000
Carlisle . .	—	—	1,734	4,503	—	—	—	—	—	—	—
Chester . .	107	409	1,368	1,100	—	—	—	—	—	—	—
Exeter . .	—	—	5,018	4,600	—	—	—	—	—	—	—
Folkestone .	—	—	—	—	—	—	—	—	—	53	33
Gloucester .	—	—	1,620	4,229	—	—	—	—	—	—	—
Goole . .	1	12	848	2,101	—	—	—	—	—	100	750
Grimsby . .	—	—	—	—	—	—	—	7	63	—	—
Hartlepool .	—	—	600	2,000	—	—	—	—	—	—	—
Harwich . .	—	—	770	1,013	21	—	—	—	—	—	—
Hull . . .	17	220	21,337	32,079	430	—	—	—	—	1,015	15,901
Ipswich . .	—	—	10,227	20,318	—	—	—	—	—	—	—
Llanelly . .	10	60	—	—	—	—	—	—	—	—	—
Lowestoft . .	—	—	200	500	—	—	—	—	—	158	433
Lynn . . .	—	—	4,044	8,004	—	—	—	—	—	—	—
Middlesborough } .	—	—	402	409	—	—	—	—	—	14	17
Newcastle . .	346	1,513	88,270	214,581	161,100	—	—	245	1,226	70	500
Newhaven . .	—	—	—	—	—	—	—	—	—	1	35
Newport . .	—	—	60	60	—	—	—	—	—	—	—
Padstow . .	—	—	221	400	—	—	—	—	—	—	—
Plymouth . .	—	—	7,018	21,204	—	—	—	—	—	—	—
Runcorn . .	—	—	6,550	16,550	—	—	—	—	—	—	—
Shields, N. .	—	—	17,040	31,000	—	—	—	—	—	—	—
" S. .	200	650	23,511	65,903	82,000	—	—	200	1,040	—	—

Ports into which imported	Manganese		Pyrites of Iron or Copper and Sulphur Ore		Silver Ore	Tin Ore		Zinc Ore		Ore Unenumerated	
	Quantities	Value	Quantities	Value	Value	Quantities	Value	Quantities	Value	Quantities	Value
	Tons	£	Tons	£	£	Tons	£	Tons	£	Tons	£
Southampton	164	2,018	330	1,330	13,240	—	—	—	—	739	34,489
Sunderland	—	—	2,113	2,778	—	—	—	—	—	—	—
Swansea	—	—	5,279	16,264	51,600	—	—	9,448	44,812	4,800	37,161
Truro	—	—	1,641	7,707	—	—	—	—	—	—	—
Yarmouth	—	—	262	1,581	—	—	—	—	—	—	—
Aberdeen	—	—	1,003	3,349	—	—	—	—	—	—	—
Ardrossan	—	—	12,443	24,590	—	—	—	—	—	—	—
Ayr	—	—	330	840	—	—	—	—	—	—	—
Borrowstoness	—	—	365	1,055	—	—	—	—	—	—	—
Dundee	—	—	1,073	3,940	—	—	—	—	—	—	—
Glasgow	1,275	7,147	10,608	64,730	2,066	—	—	1,472	5,813	—	—
Grangemouth	—	—	4,567	9,179	—	—	—	—	—	—	—
Granton	—	—	1	4	—	—	—	—	—	—	—
Inverness	—	—	1,379	1,409	—	—	—	—	—	—	—
Leith	—	—	2,202	6,157	—	—	—	—	—	—	—
Montrose	—	—	273	300	—	—	—	—	—	35	175
Belfast	—	—	2,103	3,570	—	—	—	—	—	—	—
Cork	—	—	2,097	6,202	—	—	—	—	—	—	—
Dublin	—	—	10,683	27,425	—	—	—	—	—	—	—
Galway	—	—	146	332	—	—	—	—	—	—	—
Total	8,911	14,638	804,763	1,306,700	400,775	342	13,017	11,880	54,021	13,181	270,295

OSMIUM. Osmium, as obtained by MM. St. Claire Deville and H. Debray, has a fine blue colour shaded with grey. It forms small crystals, either cubic or rhombohedric, closely bordering upon the cubic form. It is harder than glass, which it scratches with ease. It is the heaviest body known; its sp. gr. being 22·477. Crystalline osmium is obtained by passing the vapour of osmic acid repeatedly rectified over pure carbon. The sesquioxide of osmium is frequently deposited in the tube in crystalline scales of a fine coppery red. It is permanent in the air, and consists of—

Osmium	89·13
Oxygen	10·87
	100·00

Comptes Rendus, May, 1876.

OSMIUM-IRIDIUM. This compound is very commonly met with in the auriferous and other drifts of New South Wales, in the form of minute grains and scales.

Prof. Liversidge has observed it in the gem-sand at Bingera, Mudgee, Bathurst, and other places.

Its presence in alluvial gold is occasionally a source of trouble at the Mint, for minute grains are often mechanically enclosed by the gold in melting, which by their hardness speedily destroy the dies during the operation of coining.

OZOKERITE. The following account of the mineral oil and wax (ozokerite) industry in Galicia is an abstract of a paper written by Eduard Windakiewicz:—

'The author has published an exhaustive report upon the present mode of working the oil and wax deposits of Galicia, having made a thorough inspection of them in various localities, with a view to suggesting improvements in their working, and in the welfare of the miners. There are nine districts of Galicia where oil and mineral wax are obtained, the principal being Boryslaw. About twelve thousand different shafts or pits exist, of which about four or five thousand are still being worked, and of these three thousand two hundred are at Boryslaw. The ground is divided into small lots, belonging for the most part to different owners, who let or work the pits themselves. The shafts are very close to one another, and generally, in Boryslaw, only 18 to 25 fathoms deep, the deepest being 65 fathoms. In 1873, there was obtained in Boryslaw, with nine thousand labourers, 325,000 cwt. of wax and 200,000 cwt. of crude oil; while in Wolanka 25,000 cwt. of wax and 20,000 cwt. of oil were obtained—valued together at 462,000*l*.

'Some of the pits at Boryslaw are worked by one company, others by two or three large firms, a considerable number by their own proprietors, and the rest by small

gangs of men who contract for their labour. The Jews, who form a great proportion of the populace, are actively engaged in the oil and wax industry.

'The method of working is to dig a vertical shaft down to the plastic clay, when, if the soil is favourable, and the water trifling, the sides are planked with 2-inch boards; otherwise stronger protection is necessary. So far as the clay soil extends, the walls are merely fitted with basket-work. The oil is usually found first, and the wax at a lower level. The sinking of a shaft is, by reason of the large quantity of gas emitted, always carried on with the aid of wooden ventilators and metal air-tubes, without light of any sort, and it is only when cutting out the wax that safety lamps are employed.

'The miners all wear a girdle, to which is attached a so-called man-line, which is made fast to a windlass above, so that a man may be quickly drawn up should he make a danger signal below. The dimensions of the shafts in this district are 26 in. by 32 in., and sometimes 37 in. in diameter; and 30 in. by 36 in. in the case of those protected by wicker.

'When oil has been struck, there is an end to the mining operations for a time. The opening is covered with boards, so that the well may not cool, and a primitive windlass is fitted above, by means of which the oil is lifted with a metal bucket of 60-lb. capacity, attached to a wire rope. Thirty-one gallons of oil is the mean yield daily of a well, but some give as much as 140 gallons. When the supply stops the well is usually made deeper, in order to secure a second yield. Between the marl strata and sandstone strata there are often deposits of wax, which vary in thickness from 1 to 3 inches, and on these being cut the oil flows forth. The low price of crude oil renders the wax much sought after; and in order to reach it, horizontal levels have to be made, which are so narrow sometimes as to scarcely admit a man. In the larger wax shafts five or more gangs work at a time, each consisting of four or five men, one pickman cutting the ground, one for drawing stuff to the shaft bottom, two at the windlass, and one for setting its timbers; further, a boy or woman at the ventilator.

'The method of working, in Boryslaw especially, is open to many objections. The waste of labour is great: for every man working in a shaft, there are three or four only half employed at the mouth of the well. There are no special precautions to carry away the water pumped from the mines, and consequently it is scarcely drawn out of one pit before it falls into another. The shafts are so close to one another that two neighbours often touch, if they do not dig vertically, and this is a frequent source of dispute. Moreover, the fact that there are so many small owners, each working with a minimum of capital, and insufficient supervision, accounts for the loose and slipshod way in which the oil wells are managed. The inhabitants stand very low in the social scale, and the comparatively liberal wages earned are spent in drunkenness. The dirt and squalor of the Boryslaw district is quite oppressive, and the noisome smells, absence of proper drainage, the accumulation of petroleum refuse from distillation, &c., are severely commented upon by Herr Windakiewicz.

'Both the wax and the oil are refined for the market. The wax is melted in open or steam boilers, after being washed and cleaned at a cost of 10 to 30 per cent., and then poured into moulds in masses of 1 to 2 cwt., in which condition it is sold. The oil is distilled so as to produce a good burning oil. Mineral wax is obtained for about 14s. to 18s. per cwt., and after melting is sold at 22s. to 26s.; with the oil there is far less profit, and for this reason the material has been much neglected.

'The dangers of working these wells are due for the most part to the explosive gases. The returns for three years are:—

	1871	1872	1873
Men killed	24	24	23
Men severely injured . . .	23	19	21

'The causes are set down to—(1) Too little distance between the wells; (2) faulty ventilation; (3) employment of tinned iron air-tubes, which on bending rust and perish; (4) shifting of the shafts.

'In some of the districts dynamite is used in sinking and driving, but pick and gad work is more generally employed. The Boryslaw district seems the most miserable, so far as regards the social condition of the miners themselves; but in some places, such as Plowce and Bobrka, the oil industry is said to have a beneficial influence upon the inhabitants. In Bobrka, the oil is found in sandstone, or rather conglomerate with rounded quartz particles as big as lentils, in a porous mass perfectly free from lime; this stone when burned gives off much smoke and a strong smell of petroleum. Wells sunk 66 ft. have yielded 3,000 cwt. of oil per month for a considerable time; but although at the beginning their depth was only 60 to 200 ft., as the yield became less they are made deeper, being dug sometimes 500 to 1,000 ft. A 6 or 7-inch

instrument is used for boring, and usually worked by steam. The pumps for drawing off the oil are 2-in. tubes, worked sometimes by manual labour and sometimes by steam.

'The wages vary much in Galicia, and depend upon the nature of the work; half a florin (1s.) a day, being a common wage. As to improvements in the mining arrangements, Herr WINDAKIEWICZ thinks it may be concluded that, notwithstanding the amount of gas developed from the wax, the latter may be worked with perfect safety if ventilators and safety lamps are sufficiently employed under proper regulations. Where there is wax there is also oil, but the converse does not hold good; the question whether oil can be got by mining operations is doubtful for several reasons, the principal being—(1) That with increase of oil a dangerous increase in gas may be expected; (2) by the admission of air through levels the rock is cooled, and the flow of oil may cease, as freezing of the contained paraffin renders it thick; (3) that a sudden or rapid flow of oil would be dangerous. Mineral wax is not found in America, but the oil springs of that country are far more productive than those in Galicia.

'Herr WINDAKIEWICZ concludes by suggesting that a scientific study of the Galicia districts should be undertaken, so that better plans of working may be devised; and he institutes, finally, a comparison between the yield of material in those provinces and in America.'—*Berg- und Huttenmännisches Jahrbuch*, vol. xxiii., part 1, pp. 1–133.

OZONE. (Vol. iii. p. 468). For several processes for the formation of ozone, consult *A Dictionary of Chemistry*, by HENRY WATTS, Second Supplement, p. 887.

According to JOUGLET (*Comptes Rendus*, lxx. p. 539), nitro-glycerine, dynamite, iodide of nitrogen, and chloride of nitrogen, explode in a vessel containing ozone. Powder made with picrate of potassium decomposes slowly, and ordinary gunpowder alters considerably in the course of a few weeks in an atmosphere charged with ozone.

In the *Comptes Rendus*, lxxxii. p. 157, DE CARVALHO describes an apparatus for 'ozonising the unhealthy air of dwelling rooms.' Such air is to be passed, by means of an aspirator, through a tube, in which the silent discharge of a RUHMKORFF's coil takes place; and the author is of opinion that air subjected to this treatment will be freed from the organic matter suspended therein, and its harmful characters destroyed, the ozone formed being rapidly used up in the oxidation of the floating organic particles in the air. To this paper are appended some remarks by M. P. THENARD, who says he considers it is high time that not only the public, but learned men, should be made acquainted with the erroneous nature of the views generally held respecting the action of ozone on organisms. So far from having a beneficent effect, ozone is one of the most energetic poisons known; and the grave accidents which have happened in his own laboratory do not leave the slightest room for doubt about the matter. While leaving the physiological aspects of the question to M. ARNOULD THENARD, he confines himself to stating that under the influence of ozone, even when very largely diluted, the blood corpuscles rapidly cohere, and even change their form, the pulse beats more slowly and in so very marked a degree, that in the case of a guinea pig, where the beats were nominally 148 per minute, they fell to 1-30th after the exposure of the animal for a quarter of an hour to air charged with ozone. In the present day, when medicine possesses in a knowledge of temperatures so excellent an indication of the stage of a disease, it is possible, he considers, that an agent may be found in ozone for controlling them when too high. To introduce, however, without further consideration, ozone into our rooms with the fallacious notion of thereby destroying bad air, is highly dangerous. While the most powerful poisons, when rightly administered, constitute some of our best remedies, we must first have learnt how to apply them, lest we fall into error as regards the right time for application and the strength of the dose. THENARD asks the question, Are we sure that there is ozone in the air? Its presence in our atmosphere is determined by the change in the depth of colour of prepared paper (*iodide of starch*, usually). Do we know that there are no other substances in air which can affect the paper in the same way? By passing a current of air through a gas-blast, WITTMANN obtained air which acted on the prepared paper as ozonised air does; while, however, this air disinfected putrid water without rendering it acid, ozone, so it is stated, did not disinfect it, but turned it acid. Moreover, it is known that ozone cannot exist above 200°, and yet the air modified by WITTMANN's method had been exposed to the temperature at which glass softens. Although he is not prepared to deny the possible presence of ozone in the atmosphere, he holds it rash to regard as proved what is still vague and uncertain, and, may be, dangerous. While M. P. THENARD is quite correct in drawing attention to the dangerous nature of ozone, or a modified form of oxygen gas, *active oxygen* as it has been called, to which, indeed, SCHONBEIN drew attention at an early period of his inquiries, there can be no doubt but that the changed oxygen, which is called ozone, does attack and render inert putrid air, and remove offensive odours.

M. Marié-Davy employs with very satisfactory results a mixture of iodide of potassium and arsenite of potassium for estimating ozone in the atmosphere.

After 250 litres of air per hour had been passed for 12 hours through two vessels in succession, each containing 20 c.c. of the nitrated liquid, the reaction was found to have taken place entirely, or nearly so, in the first vessel. Nitrate of ammonia present in the air did not affect the indications.—*Comptes Rendus*, lxxxii.

OZONE GENERATOR. Dr. F. W. Bartlett, of Buffalo, New York, has invented and patented an apparatus for generating ozone from phosphorus. In the first place he forms the sticks of phosphorus thin and flat, their height varying with the size of the machine and tubes employed.

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The walls of the ozone chamber are composed of an inner and outer wall of wire or other open work, the inner one of much finer texture than the other. Between the two, and surrounding the entire chamber, is arranged a porous fabric saturated with an alkali.

In the drawings, *fig.* 2441 is a vertical and *fig.* 2442 a horizontal section of the ozone apparatus. A is a glass vessel or base, having on its inner face a number of projections, as shown in *fig.* 2442, which have the effect of dividing it into tubes when the plunger, B, which is a cylinder of glass, is introduced, as seen at *fig.* 2441. This plunger is hollow, and open or closed at the bottom in accordance with the method employed for altering the water level. If the plunger is raised up and down then the bottom is closed, but if the plan shown in *fig.* 2441 is preferred, then the plunger is hollow and the phosphorus sticks are themselves raised or lowered as may be desired. The device employed for the latter purpose consists of a central or

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sustaining wire, C, with a branch passing into each cavity or tube, and curved or bent at the extremity to hold a single tablet or stick of phosphorus, F. The central wire will pass through the ozone chamber, G, and the expansion dome, D, to a hollow stopper, E, placed at the top of the apparatus. Its upper end will have a screw thread passing into a nut fixed in the lower end of the hollow stopper, and the altitude of the phosphorus will thus be regulated by simply moving the stopper right or left.

Above the glass generating chamber or base, A, is arranged an ozone chamber, G, its walls being formed of two thicknesses of wire-cloth or perforated material of suitable quality, and having between the outer and inner walls thus formed and surrounding the entire chamber, cotton, linen, wool, paper, silk, or other fibrous, porous, or similar substance, which is first treated with or saturated in an alkali or other suitable chemical in such a manner that the latter is retained in the fibres of the stuff, so that the products of the oxidation of the phosphorus, except the ozone, may be confined to the generating chamber or neutralised by the chemicals employed, the ozone, on the contrary, passing readily outward to mingle with the atmosphere of the room. This delivery of the ozone through the walls of the chamber is based upon the discovery that the specific gravity of ozone is greater than that of the atmosphere, and that when passing from a chamber or space it will naturally do so from the middle and lower part of the same. All the air necessary for the combustion of the phosphorus will also pass readily through these walls, and no other means for air ingress is provided.

The absence of draught or force of any kind in the delivery of ozone, and the peculiar construction of the chamber, O, are the important features of Dr. Bartlett's invention. To prevent any pressure upon the lateral walls of the ozone chamber, O, a glass dome or expansion chamber, D, is set above the ozone chamber to receive the surplus products of oxidation, and allow them time to fully vaporise and form the ozone. In the dome the 'antozone,' or cloud of oxidisation, is very plainly visible, but the ozone, as it passes quietly out from the ozone chamber, O, is invisible to the eye, but is at once detected by the sense of smell and the characteristic ozone tests. The special arrangement of the tubes around the base of the machine is designed to increase the safety of the operation. As each stick is thus exposed to view its height above the water is seen at a glance, and its position when submerged can always be plainly seen. The tubes, with the vessel, A, the plunger, B, and dome, D, should be of glass, to resist corrosion. The prepared porous stuffs are renewed as often as necessary, the adjacent parts of the machine being made removable for that purpose.

P

PACHNOLITE. (Cryolite, vol. i. p. 1012.) This mineral occurs with cryolite in Greenland in large colourless granular crystalline masses, exhibiting here and there in drusy spaces symmetrically developed crystals. Analysis shows *pachnolite* to be a hydrated cryolite.—F. Wöhler, *Jahrb. f. Min.*, 1876.

According to the *Transactions of the Royal Academy of Sciences of Göttingen*, its composition is—

Aluminium	13·42
Calcium	17·64
Sodium	10·75
Water	8·20
Fluorine	49·78
	100·00

PALLADIUM. (Vol. iii. p. 473.) Professor Wöhler communicates to the *Göttinger Nachrichten*, No. 20, 1876, some remarkable experiments on the action of the flame of alcohol upon this metal.

It appears that palladium, both in the spongy form and in that of foil, becomes gradually covered with a thick coat of carbon when held in the flame of a spirit-lamp. A small piece of palladium sponge thus heated swells up to many times its own volume, cauliflower-like branches of carbon being deposited on the surface of the metal. The same phenomenon is observed if the metal be allowed to glow in a coal-gas flame. When the adhering porous mass of carbon is allowed to burn away, a fine skeleton of palladium remains behind; and this is the case even if the carbon has been deposited upon a piece of foil, which is then found to have been penetrated through and through with carbon and rendered quite brittle.

If palladium sponge, when saturated with hydrogen, be brought into the air, it becomes red hot. Palladium which has become of a bluish-green tint from ignition in the air becomes hot when plunged into hydrogen and assumes the original grey colour of the metal. In the original memoir several interesting facts connected with the occlusion of gases are named. See *The Action of Palladium on Carbon*, by Thomas Wood, Göttingen, 1859, and a translation of Wöhler's paper in the *Philosophical Magazine* for December 1876. See Platinum.

PALMETTO. *Sabal* or *Chamærops Palmetto*. There are several species of the palmetto growing in the Bahamas and other tropical islands. The leaves of one variety (*Sabal Mexicana*) are extensively used for thatching the houses of the poor people. The leaves of another sort (*S. Palmetto*) are used for making hats, baskets, brooms, &c., and those of a third sort (*Sabal Adamsoni*) are employed in the manufacture of fans, table-mats, and handsome ladies' hats. For this purpose the leaves, after they are dried, are stripped into ribands of the size required and plaited, and the plaits are then sewn into the shape required.

For rope-making the palmetto top leaves are gathered green, carefully dried, and then cut with knives into small thread-like strips. These are spun, in the Bahamas, with a rude spinning-machine into rope. This rope is generally covered with strips of leaves of about half an inch wide, for the purpose of making the rope more durable.

PAPER BARRELS. Barrels are now constructed in the United States of paper, and used for the carriage of dry materials, such as sugar, rice, flour, and the like.

These barrels are made of successive layers of paper board cemented together and subjected to enormous pressure, the result of which is a compact substance possessing great resisting power. The paper used for this purpose is made of straw. The barrels are perfectly cylindrical in form, which gives them an advantage of 25 per cent. in storage over wooden barrels. Their weight is about half that of a wooden barrel. It is stated that they will stand four times the pressure that a wooden barrel will, but we have reasons for doubting the strict correctness of this. Two factories are now engaged in the manufacture of these barrels, one at Winona, Wis., and another at Decorah, Iowa. At the latter factory 1,600 barrels per day are said to be turned out, with a consumption of five tons of paper. It is claimed for them that they can be made 20 per cent. cheaper than wooden barrels. They may be rendered absolutely air-tight, and it is claimed that they will resist moisture longer than they are likely ever to be exposed to it.

PAPER FROM FLAX. The *New Zealand Gazette* informs us that the New Zealand flax is now being employed for the manufacture of good serviceable wrapping-paper, of cardboard, and roofing for houses.

The mills for carrying out these operations have been named the Kaihu, and are situated in the district of Northern Wairoa, where a very considerable plant has been erected.

The paper produced is of a fine close texture, and almost as strong as parchment; it will tear but not break, and the prepared material for roofing purposes is not only of superior adaptation in point of quality to the usual descriptions of felt, but is furnished at a much lower price.

PAPER, JAPANESE. Most persons are familiar with the peculiar character of the Japanese paper; we are indebted to Professor HENRY S. MUNROE for a description of the process of its manufacture. The Professor exhibited at the New York Academy of Sciences specimens of this paper, and described the materials employed and the method of manufacture. The Japanese paper is made from the inner bark of the mulberry tree. It is never bleached, but made as clean as possible; hence its faint yellow green or pinkish colour. Paper is made in small villages where all the inhabitants are paper-makers. The sons of paper-makers follow the profession of their fathers unless adopted into a family pursuing some other vocation. The paper mulberry tree, of which the paper is made, is propagated by cuttings from the roots, which are planted on the borders of rice-fields, and they mature in about five years. In November the reeds are cut and sold to the paper-makers; and the roots are left to send up new shoots. The shoots are cut in pieces 3 feet long, piled up, and allowed to ferment, which loosens the bark so that it can be stripped off, after which they are dried in the open air or scraped at once. The scraping removes the brown epidermis, which is used for inferior wrapping-paper. About 33 lb. of the bark is boiled for two hours in a strong lye of wood ashes. It is then put in bags and left in a running stream until the alkali is completely removed. It is next beaten, 2 lb. or 3 lb. at a time, on a wooden block with heavy sticks, for 15 or 20 minutes. This pulp is mixed with a little rice paste, or a paste from a species of mallow. A thin pulp is obtained by stirring ¼ lb. of this mass into 40 or 50 gallons of water. The web or mat on which the paper pulp is collected is made of slender strips of bamboo only the thirty-sixth part of an inch in diameter; several hundred of these are bound together with silk threads; the rods all run lengthwise of the sheet, and hence the mats can be rolled or folded up in one direction. For coarse paper reed-mats are employed. The process of manufacture is essentially the same as in making handmade paper. A woman sits in front of the tank and stirs it vigorously, then dips a mat and frame into the vat, takes up some of the pulp and shakes it, so as to arrange the fibres parallel. A single dip makes a very thin tissue paper; most paper is made by dipping twice and draining each time. After the second dipping the mat is stood up edgewise by the side of the tank to drain, and the frame put on a second mat, which also receives its first dipping. While the second sheet is draining for the first time, the mat with the first sheet is laid face down on a pile of finished sheets with a rice straw between them. While the second sheet is draining a second time, the mat is taken off from the first sheet, so that only two mats are necessary. When 500 or 600 sheets, which form a day's work, are completed, they are pressed for some time with heavy weights, then taken up one at a time, by means of the rice straw, and placed on smooth boards to dry in the sun. When dry the sheets are stripped from the board by a sharp knife with the blade at right angles to the handle like a sickle. The finished paper weighs about one-half as much as the bark employed.

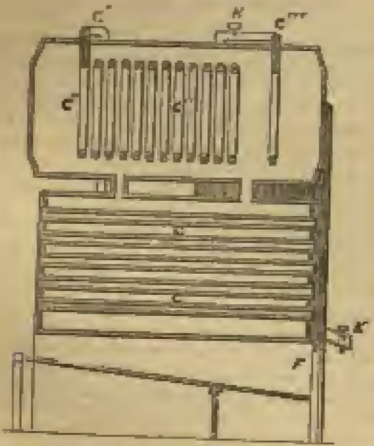
The uses to which the Japanese put this paper are various in the extreme. Almost everything that is not subjected to any severe usage is manufactured from paper prepared by several chemical processes, many of which are exceedingly ingenious.

The Japanese have several processes for rendering paper waterproof and for giving great strength to it.

PAPER-PULP MACHINE. *Improvements in the Manufacture of Paper Pulp.*—This invention of Messrs. DOWNING and HUGHES, of 4 Lambeth Hill, Queen Victoria Street, relates to improved means or apparatus for the reduction of paper-pulp from wood, straw, or other vegetable fibre.

A digester for reducing the paper pulp is employed, provided with an upper and a lower perforated diaphragm, between which, through suitable openings, capable of being closed when desired (formed in the upper part of the digester, and in this upper diaphragm), the 'stock' wood, straw, or other vegetable fibre is introduced in order to its being acted upon by the alkaline solution or liquor. This liquor is poured thereon through the openings in the digester and upper diaphragm described, until the stock is covered or the digester is nearly full. These openings are then closed, as well as another opening at the lower part of the digester above the lower diaphragm provided for the exit of the stock when desired. Connection is now opened into a pipe leading from the bottom of the digester below the lower diaphragm to a fan pump driven by suitable driving means, by which the liquor flowing from the digester is forced through suitable piping to a coil or coils or chambers placed within a steam boiler or heating vessel. This steam boiler may be formed in two sections, the chamber or chambers for heating the alkaline liquor being placed in the upper one.

2443



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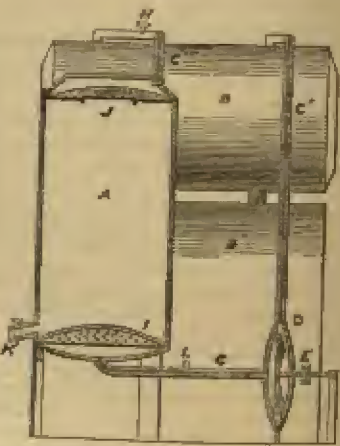


The liquor is highly heated in the course of its passage through the coil or chamber or chambers from the digester by contact thereof with the steam or hot water of the boiler, and is thence conducted through another opening into the upper part of the digester, and through the upper perforated diaphragm and the contained 'stock' and through the lower diaphragm to the lower part of the digester, and by the pipe communicating with the fan pump is again forced to the heating coils or chambers in the boiler to be heated again, and so on. By these means a continuous circulation is kept up by the fan pump, driving forward the liquor as it flows from the digester, obviating the difficulty hitherto experienced from the suction of the fine pulp into the openings in the lower diaphragm of the digester, and the consequent prevention of the circulation of the liquor, and the coil or chamber is not subjected to the direct burning effect of the furnace fire, nor its contents to danger of evaporation from the intense heat of the fire.

Fig. 2444 is a vertical section of the two sections of steam boiler, in the upper one of which the coil for heating the alkaline liquor is situated. *Fig.* 2443 is a similar view of the digester, connecting parts of the coil of pipe and the fan pump, also showing *fig.* 2444 in elevation.

A is the pulp digester; B B, the two sections of the steam boiler; C, C′, C‴, the connections of the coil of pipe, C″, with the digester; D, the fan pump located between pipes C and C′; E, pulley for driving the pump, D; F, the furnace for heating the steam boilers; G, the tubes of tubular boiler, B′; H, a cock; I, J, lower and upper perforated diaphragms in the digester, A, and which contain the stock to be reduced

between them. This stock, wood, straw, or other vegetable fibre, is introduced through a man-hole in the upper diaphragm, J, and finds exit through the opening, K, which is secured by a valve or cock. In practice the lower diaphragm, I, is slanted towards the opening, K, to facilitate the removal of the pump after the operation is complete; L is a cock to stop the flow of alkaline liquor into coil C''.

The apparatus is operated as follows:—The stock, wood, or straw, or other vegetable fibre to be reduced to paper pulp is introduced into the digester, A, between diaphragms I and J through the opening in the top of the digester, and the man-hole opening in the diaphragm, J. The exit opening, K, should of course have first been closed. The alkaline solution or liquor is then poured into the digester on the stock, until the stock is covered or the digester nearly full. The man-hole in the diaphragm, J, is then closed, and the top of the digester also. The cock for the supply of the liquor, L, being open, will then have filled pipe C' to the height of the liquor in the digester. The boilers, B,' B' (which in many cases would be the ordinary steam boilers employed in actuating the motive parts of the machinery of the mill), are then steamed up, and the coil of pipe, C'', in boiler, B, is thus heated by contact with the steam and hot water therein. The fan pump, D, is then started by the belt on pulley, E, and the alkaline liquor is thus projected through the pipe, C', into the coil, C'', in the boiler, being highly heated in its passage through the latter, thence through open cock, H, into the digester through the diaphragm, J, and the inner contained stock through diaphragm, I, and open cock, L, on pipe, C, to the fan pump, D, to be once more projected through the coil. The great body of the alkaline liquor makes this operation continuous. Thus a continuous circulation is kept up. The pump, D, being a fan pump, simply drives forward such liquor as flows into it from the digester, thus obviating a difficulty heretofore experienced, viz., the suction of the fine pulp into the openings of the lower diaphragm, I, of the digester, and the consequent prevention of the circulation of the liquor.

PAPER WHEELS. That exceedingly useful material, paper, has been applied to almost every purpose. Paper barrels, already described, have been made of millboard, impregnated with some resinous substance, or in some cases saturated in the first place with gelatine, then with bichromate of potash. The boards thus prepared are exposed to the action of light, when the gelatine is converted into a kind of leather which is quite impervious. It is only very recently that we have heard of the application of this material to railway wheels. The paper wheels as now manufactured have steel tires, made with an inside flange and cast-iron boss. On each side of the boss and tire, steel plates, 3-16 in. thick, are bolted, and the space between the plates is filled with compressed paper. The paper is composed of what are known as 'straw boards,' and these are made to adhere to each other by means of rye paste. The combined layers of paper are subjected to hydraulic pressure to the extent of 2,000 tons for the space of four or five hours, and then dried in a heated air-bath. The final thickness of the prepared paper is about $3\frac{1}{2}$ in., and, as may be imagined, the quantity of straw-board packed into this space by the giant force of the hydraulic ram is something enormous. Still a certain amount of elasticity remains, and this—in union with its homogeneity and singular smoothness of grain and texture—constitutes one of its highest qualifications for the duty it will have to perform. Lathes, slide-rests, and sharp-cutting tools are made to shape the compressed paper into discs of the proper size, and under a pressure of 400 tons these are then forced into the tires. The steel protecting plates are subsequently bolted to the inner and outer peripheries of the wheels, and after a finishing touch in the latter they are ready to be keyed on their axles and placed under the railway carriages. It is understood that experiments, both in America and in this country, prove the great superiority of paper railway wheels, and that the brake, however suddenly and sharply applied, does not injure them.

PAPER IMPORTS AND EXPORTS for the years 1875 and 1876:—

Paper Imports, 1875 and 1876.

	1875		1876	
	Cwt.	Value	Cwt.	Value
For printing or writing . .	187,964	£442,739	259,610	£631,113
Paper hangings	9,797	69,264	14,507	69,535
Brown or waste	—	432,365	—	405,969
Millboard or pasteboard . .	286,529	161,062	318,504	177,750

Paper Exports, 1875 and 1876 (British Production).

	1875		1876	
	Cwt.	Value	Cwt.	Value
For printing or writing	212,430	£687,194	193,093	£619,890
Paper hangings	64,434	191,410	56,387	166,499
Millboard or pasteboard	13,254	34,251	11,727	29,285
Unenumerated articles of paper	93,207	222,419	82,315	204,783

Paper Exports (Foreign or Colonial Produce) for 1875 and 1876.

	1875		1876	
	Cwt.	Value	Cwt.	Value
For printing or writing	21,004	£51,806	21,479	£50,033
Paper hangings	133	839	280	2,390
Millboard or pasteboard	3,600	2,337	3,306	2,233
Unenumerated articles of paper	—	28,363	—	—

PARAFFIN FROM WOOD. In Sweden the manufacture of illuminating oil from wood has become a large and successful industry. The roots and stumps of trees are employed for the purpose. The wood is subject to dry distillation, with exclusion of air, and a variety of products are formed which are of value in the arts. Among these may be mentioned turpentine, creosote, tar, acetic acid, charcoal, oil of tar and oil of wood. The wood oil cannot be burned in an ordinary lamp, but a camphene lamp can easily be adapted for the purpose. It is not explosive and is remarkably cheap. The pine tree is the best adapted for distillation, and there are 15 establishments in operation in Sweden, 3 of which produce 15,000 litres (667 gallons) of oil annually. (See PETROLEUM.)

In 1875 and 1876 we imported of paraffin—

	1875		1876	
	Cwt.	Value	Cwt.	Value
From Germany	15,680	£52,232	14,380	£50,761
" United States of America	11,405	23,682	22,784	53,862
" other Countries	430	1,014	639	1,819
	27,515	£76,928	37,803	£106,442

PARACRESYLIC ACID. Used for the preservation of meat, in the proportion of 1 part in 516 of water.

PAREMENTINE. The name given to a new dressing. It consists of 100 parts glue, 20 of dextrine, 20 of glycerine, 20 of sulphate of magnesia, and 20 of sulphate of zinc, with the needful amount of water.—REIMANN'S *Färber Zeitung.*

PÂTE-SUR-PÂTE. A process of decorating porcelain vases. In this process the artist paints upon the unfinished vase with a white clay, which after firing appears either semi-transparent or opaque, according to the thickness with which it is laid on, and this permits the delineation either of solid figures or of the lightest drapery. When applied the clay is opaque, so that great judgment and experience are required.

PEARLS, CONCH. (*Perles de conque*). The Bahamas export to this country a few pearls found in the pink-lipped concha. They are found by the fishermen in the Bahama waters near the coast. They are generally taken to Nassau, where they are sold for exportation.

The value of these pearls depends upon their form and colour. Those perfectly round or oblong are preferred, with a light pink colour and a wavy surface. The Reporter on the Bahamas to the Vienna Exhibition, states: 'One of these pearls recently brought 80*l.* in the London market, but the price generally varies from 2*l.* to 30*l.*'

PEAT. (Vol. iii. p. 521). Mr. HENRY CLAYTON'S name has been long associated with the preparation of peat. His process has been already referred to in vol. iii. p. 526. This gentleman has of late years been drawing further attention to some improved forms of apparatus invented by him for comminuting, pulping, and condensing peat.

The following is a description of his process and machinery:—The raw peat as dug is filled into the patented arrangement of 'squeezing' trucks, which have perforations in the sides for the escape of the free water. A piston forced against the peat in the truck by the aid of a screw and lever effects a pressure upon the body of the peat, and during the passage from the bog to the machine the peat is thus freed of no inconsiderable portion of the water. The trucks are drawn up to the machine by convenient hoisting gear.

The machine for 'masticating' the peat (*i.e.* cutting it up into very fine portions) consists of a vertical chamber in which revolves a shaft, having fixed upon it a series of screw-like blades, the action being somewhat similar to an ordinary pug or tempering mill. The rough peat from the squeezing trucks is fed into the hopper of this chamber, and by the action of the blades is broken up and forced downwards into the comminuting apparatus. In treating stony peats an arrangement of 'screening' may here be introduced, by which the stones are arrested and separated from the peat.

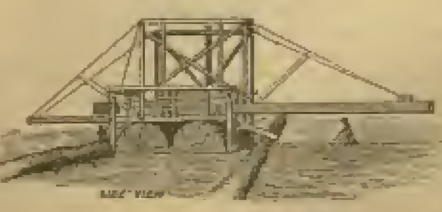
A horizontal cylinder forms the body of the machine, and is fitted with a central revolving shaft, upon which are fixed propelling screws, as also a series of curved arms or discs, so arranged upon it that in their whole length they form a dissected double helix, with increasing spiral. Along the bottom of this cylinder, and projecting upwards towards the shaft, are arranged cutting blades of hardened steel, between which the discs pass in their revolution.

The peat thus fed into the cylinder by the joint action of the blades and screws is carried along by the discs in their forward movement, each revolution bringing the peat against the cutters, and thereby effecting a complete 'masticating' process, by which the fibrous tissues and cellular structure are effectually destroyed, the rooty and other undecomposed portion of the peat reduced to a state of fine pulp, and the whole mass of the peat brought into a uniform condition of homogeneity.

The peat is by these means gradually prepared, pulped, and worked forward to the delivery end of the cylinder, whence it is expelled by the continued screw motion issuing through suitably-shaped orifices in continuous streams on to a special receiver. This consists of a number of rollers which receive the exuded streams of moulded peat; and over these the peat travels until it arrives at a point where the ends of the moulded peat-streams leave the rollers and pass on to a portable lathed tray, suitably located under the rollers to receive them, and carried on fixed wheels, of which there is a continuous forward series, so that the moving peat imparts motion to the tray, thus pushing it forwards from under the rollers until the tray is filled with the moulded peat. A boy then cuts off the lengths of peat which are on the tray from the exuding mass, and places another tray in position to receive the next batch. The tray, with its charge of peat, then passes down an inclined guide or tramway in the direction of the drying-sheds, and at a convenient point upon the guide the moulded peat is again cut up into the desired lengths of bricks or blocks. The passage of the charged tray then continues down the tramway to the drying-racks, where the moulded peat upon the tray is put to dry. In about three days the peat bricks become sufficiently dried to permit of their being taken from the portable trays and stacked in open racks of special construction, where they remain to complete the drying.

An exceedingly simple process for preparing peat fuel has been for some time in use in Canada, and has been thus described by Major-General Sir James Alexander; *figs.* 2445 and 2446. A large barge was fitted up for cutting, cleaning, lifting, and distributing the peat. The barge is floated in a channel of water, which it forms as it proceeds. Two screws in front cut and draw in the peat, and working in opposite directions draw the barge forward; at the same time the peat, cut, and

2445

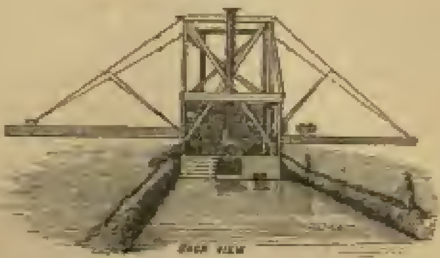


sucked in, is dredged up by a masticating process, and all roots and indigestible matter being duly separated, the resulting pulp is ejected through a long telescopic tube over a considerable area of the bog on each side of the channel. After it has hardened sufficiently, it is cut up into pieces of convenient sizes and shape, and these pieces are stacked well together to dry in the sun. No other preparation is required, nor is any artificial drying necessary, consequently a fuel, growing on the spot, is most economically obtained.

The figures referred to are intended to give a front and a back view of the arrangement introduced by Sir James Alexander, and adopted in Canada along the Grand Trunk Line of Railway, in the locomotives of which line much of this dried peat is consumed.

This system succeeds perfectly when the sun is sufficiently powerful to dry the peat, which should be placed under cover not later than October. The peat burns well in steam locomotive engines, and has been largely used for raising steam in fixed steam boilers.

2446



HALL *and* BAINBRIDGE'S *Process*.—The conversion of peat into fuel and charcoal formed the subject of a paper read November 1876, before the Society of Engineers, by Mr. CHARLES E. HALL. The processes described by Mr. HALL are those in use on the Fells in Teesdale, at the works of the LONDON LEAD COMPANY. They are thus described:—

'The LONDON LEAD COMPANY'S peat works are situated about 1,700 feet above the level of the sea, at Little Eggleshope, and at the lower extremity of the peat bog; so that the crude material is run down a short incline and tipped direct into the machine. The labour cost per ton has been 5*s*. 6*d*., but this item will be proportionately decreased as the output is increased; and so with the item of interest on the capital expended, which is rather high, and could be materially lowered by an increased production, of which the works are capable. The amount of moisture in the peat is from 75 to 80 per cent., as shown by results, which give 1 ton of dry fuel for every 4 tons of crude material. Every ton of charcoal made from condensed, but not thoroughly air-dried, peat, containing say 50 per cent. of moisture, costs about 25*s*., and requires from 4 to 5 tons of such material. It should be remarked, however, that it is not so rich in carbon as the Irish peat, although good as a gas producer, the gas approaching in illuminating power to Newcastle coal. The operations which make up its first cost are: clearing the top, which is used as fuel for the engine and carbonisers to a large extent; digging and loading the trucks, conveying the same to the machine by tramways, treatment therein and removal therefrom, its disposition in the drying sheds, the labour in turning it over, and its final removal to the store. The author believes that every item of superfluous labour has been eliminated from this calculation, which is based upon the working at Middleton, where advantage is taken of the different levels. One process follows upon another in one unbroken series until the material is ready for use. The store is situate immediately under the drying sheds, being open on the two sides, and the floor trellised at the top, so as to give a free current of air and perfect ventilation.

'There are six sheds, 15 feet span of roof, making a total width of 100 feet, open from side to side, inclusive of gutter spaces. These sheds are 200 feet long, covering an area of 20,000 square feet. The sheds are filled with racks, placed across the sheds back to back, leaving a pathway between. There are twenty racks of six tiers high, holding 672 trays each, or a total of 13,440 trays. A tray of wet peat weighs 56 lb., and a tray of dry peat 14 lb., giving an evaporation of 75 per cent.; whilst the remaining fuel may be still said to hold 20 per cent. of moisture. The material is dug out higher up the Fell, and brought by an incline a distance of 100 yards in ordinary contractors' tipping trucks, the squeezing trucks originally supplied being useless for peat containing not more than 80 per cent. of moisture.

'There is another question which tells seriously against the cheap production of peat fuel, and that is the short season available in this country for drying. This is generally from May 1 until towards the end of September, and in favourable years towards the middle of October—say six months. The whole interest for twelve months, besides depreciation, has to be charged on to the six months' working. The adoption of shedding is not without its defects, for the working at Middleton has proved that the peat stored in the racks to the outside of the sheds, and to the windward, dries in much less time than the bulk of the peat stored in the centre. The author believes, therefore, that sheds should be independent of each other—ranged in lines, but with distinct roofs—so as to secure a good circulation for the air. In dry

weather sheds are a mistake. The chief advantage arising from the use of shedding is that the labour in piling and stowing away the peat is concentrated and reduced to a minimum, and is therefore cheaper; but against this item should be put the interest and depreciation of 1,000*l.* at 10 per cent. on the output. If sheds are adopted, then provision should be made for conveying the air by channels underneath, such air being caused to travel over heated pipes or flues, in such manner as to dry it, increase its temperature, and cause draughts. But as the heat to do this, in the first instance, must be obtained at a considerable cost for fuel, it is objectionable, unless it is obtained in the manner the author will explain, and which has been provided for, though not yet carried out, at Middleton. That consists in the conversion of a considerable portion of the fuel into charcoal, the waste heat resulting from the process being conducted through the flues under the sheds to a chimney stack, the air being distributed at various points. Experience has shown that warm dry currents of air, with a temperature of from 80° to 90° Fahr., freely circulated, is the most effective medium for absorbing moisture from peat. Bearing in mind that peat must be dried where it is grown, and the two results requiring two directly opposite conditions, it is a mistake to erect extensive shedding. Mr. Bateman has found it preferable, after a short exposure in the sheds, where a skin is formed, to turn the peat out in the open, and so complete the process. The whole system of sheds, working and construction, has received much modification; and in dealing with peat, the author has come to the conclusion that the less tearing and manipulation given to it, the better will the product be, so long as the process has been effectual.

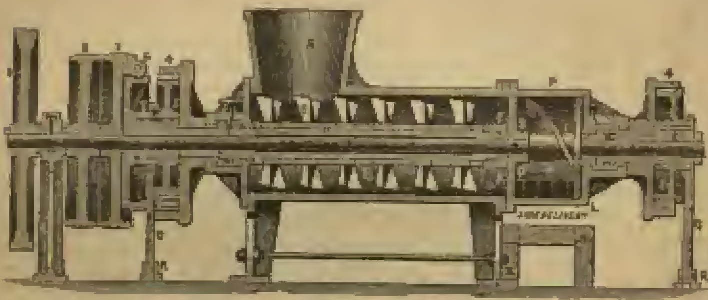
'One of the objections at Middleton to the Clayton machine was that it damaged the peat, the process being too long. In the machine designed by the author the duration of the process is considerably shortened, the cutting action greatly improved and simplified. Another objection which it has been attempted to improve is, that when the peat was at all fibrous and strong, it was lashed on to the fixed knives of the Clayton machine, which soon became so clogged that no useful result was obtained; indeed, the treatment of peat in an enclosed barrel is very difficult. The internal, or skin resistance of the tube, being less than the internal resistance of the peat, the balling up of the propelling apparatus is the consequence; whilst, when too much artificial resistance is afforded, a corresponding amount of slip is the result, and this appears to be frequently the case in the Clayton machine. From the fibrous nature of peat, especially such as is found in England, and the difficulty of extracting its moisture, the author concludes that but two operations, and those of as short a duration as possible, are required. The first is the pugging, or mixing and collecting process; the second is the cutting or bleeding process, after which it is delivered with the air discharged, and the water mechanically combined with the solid matter, permitting free evaporation.

'The question of the drying of mechanically *versus* hand-prepared peat has often been debated; and it is asserted, with some show of reason, that the hand-worked peat has the advantage in point of time. The author admits that this is true with regard to the mechanical systems mostly in use; for any machine which merely kneads or mixes up the crude materials, such as pug-mills, &c., merely liberates the loose or surface moisture, imprisoning by far the greater portion of hygroscopic water within an impervious skin, and rendering its exit far more difficult. According to Mr. Hall's system of treatment, the presence of air and water in the numerous fibres is destroyed, and the complete separation and disintegration of every particle and fibre is secured, the continuity of each fibre is destroyed, and the constituent parts are placed in new positions. The cutting, which is done quickly and at one operation, thoroughly bleeds the moisture out, liberates the air, and immediately condenses the mass without pressure, leaving it uniformly saturated with free moisture, in which case a less time is required for drying; it is dried more effectually, and the fuel is concentrated to its utmost extent, presenting a solid coherent mass, suitable for any purpose.

'*Fig.* 2447 is a sectional elevation of the machine. Referring to the drawing, it will be seen that the machine consists of a cylindrical casing or barrel, B, about 1 foot 6 inches in diameter and 4 feet long, with feed-hopper, A, at one end. Through the centre of this barrel work two shafts on the same axis, marked respectively I and C, having thrust bearings at each end of the machine. The high speed cutter-shaft, I, works through the hollow or pug-shaft, C, and turns in the same direction. The pug-shaft, C, is of octagonal form outside. Upon it are placed screw-like blades, which pass between projections attached to the casing. The outer shaft, C, takes its bearing in the diaphragm or port-plate, F, through which the peat is forced by the blades, E. This is seen better in *fig.* 2448. A four-winged cutter, similar to a chaff-cutter, D, rotates past these ports, being held close up, and cuts off into short lengths the slowly protruding peat, against the four arms or cross-bars. When the delivery is at right angles, as shown in *fig.* 2447, the cutter-shaft, I, has a slowly revolving screw-like

wiper, *s*, in the delivery-casing, *v*, and with this is cast the circular and plate, *t*, against which the condensed peat is forced and delivered at the orifice, *t*. The wiper and plate, *s* and *t*, are driven by separate gearing, and may have a faster or slower

2447



motion than the pug-shaft, c. The peat is delivered in a continuous stream on to wooden trays, T, placed on a trestle, x, having rollers, w, mounted therein. The trays are 3 feet long by 18 inches wide, and are propelled forward by the issuing stream of peat. A counterbalanced cutter, T, working in guides, and operated by the attendant by hand or foot, enables him to cut the bricks of peat into any length; this dispenses with the wire-cutting frame of Messrs. Clayton, found to be so inconvenient. The speed of the cutter-shaft, I, is 110 revolutions per minute, whilst the pugging-shaft, c, is 11 per minute, and these motions are effected by differential gear, shown in section at *fig.* 2447. An eccentric is formed on the shaft, I, marked 2. A wheel, 3, having, say, thirty teeth, is mounted loosely on it. An internal toothed wheel, 4, is keyed fast to the outer shaft, c, and has, say, thirty-three teeth. The throw of the eccentric is such as to cause the pitch lines of the two wheels to exactly coincide as the eccentric revolves, but the wheel, 3, is prevented from turning round by the tail-lever, 2, to which it is firmly secured and held in the bracket, R, in which it slides. The action of this is to revolve the outer wheel, for each revolution of the eccentrically-mounted pinion, in the proportion of the difference of their teeth. It may be termed an internal sun-and-planet motion. Motion is given to the belt-pulley, 5, and transmitted through a friction strap and drum, 6, to the pinion, so that the driving can be nicely adjusted to the power required for treating the peat. In the event of any foreign substance being present, or any undue strain being brought on the machine, it will slip, and thereby call attention to it before damage is done.

2448

'*Fig.* 2448 is a vertical cross section of the machine taken behind the diaphragm plate, and showing the construction and action of the rotary cutter. This shows the end view, and illustrates the action of the differential gear, and the delivery of the condensed peat.

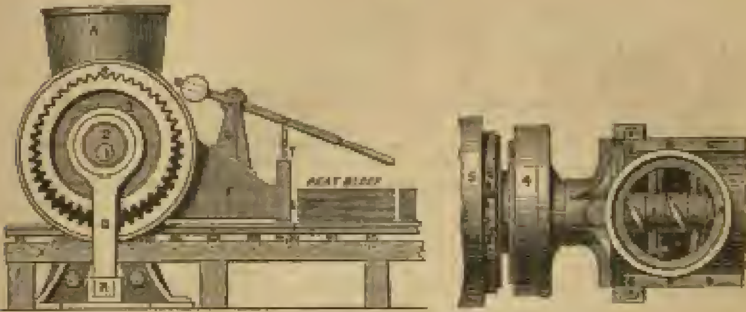
'*Fig.* 2449 shows an end view of the delivery orifices, *t*, and the counterbalance cutter, T, with balance weight, z. In conjunction with the machinery just described, it is not only desirable, but almost indispensable, that a system of carbonisers should be worked, producing as much charcoal as possible. This is the most valuable form in which peat can be introduced, and in which it is most universally applicable.

'Making charcoal the leading feature of manufacture will enable the ordinary labour employed to be engaged in profitable production for a longer period of the year, and to a large extent independent of the weather—the great enemy to contend against in peat works. It also allows a greater number of machines to be worked during the summer months, stocking the surplus production of condensed peat for conversion into charcoal during the winter, and largely enhancing the total output per annum, in proportion to the necessary plant required; thereby reducing the interest charges per ton of fuel made, and guaranteeing continued employment to the permanent staff engaged on the works.

'When the situation allows, the waste heat given off from the carbonisers can be

utilised in raising the temperature and drying the currents of air passing into the drying-sheds, by conducting such waste heat through a series of flues, under the sheds

2449



to a chimney-stack. Experience has shown that dry warm currents of air, with a temperature of from 80° to 90° Fahr., freely circulated, is the most effective method of absorbing moisture from peat. It will be clearly seen that, as peat bogs owe their existence to a wet, humid atmosphere, and manufactured peat must be dried where grown, if a counteracting drying action can be given to the currents of air passing through the sheds, without a *direct* cost of fuel to produce such effect, the benefit derived therefrom must greatly facilitate the evaporation of moisture from the prepared peat-blocks, making the process more continuous and increasing the output.

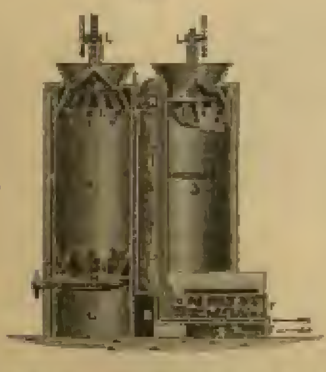
'This, however, can best be applied where a systematic arrangement of permanent sheds is adopted; but experience has shown that in some measure a continuous block of sheds has many objections.

'Artificial drying *alone* can never be successfully applied, for with an article of such comparatively low calorific value, and containing so large a percentage of moisture in its raw state, it would require three-fourths of its own heating-power to make it available as a fuel. Any artificial heat applied from even waste products of combustion must, therefore, only be auxiliary to the natural atmospheric drying.

'Referring to the system of carbonisation, we will now describe a new system devised in connection with this peat machinery, which, being continuous in its action and economical in its operation, has many advantages over the more crude methods usually adopted.

'*Figs.* 2450 and 2451 illustrate this system, which consists of a group of vertical chambers or retorts, marked Nos. 1, 2, 3, and 4 in *fig.* 2451, which is a sectional plan

2450



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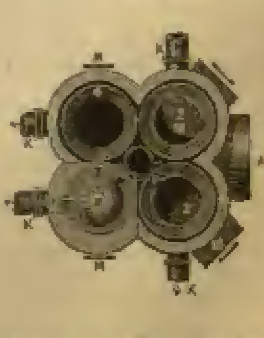


taken at various parts. *Fig.* 2450 is a sectional elevation of the apparatus, *fig.* 2451 a plan: there is one large chamber, A, which is common to all the retorts, the products of combustion from which pass under an inverted fire-bridge, B, to the central tube of

flue 5. The necessary oxygen to consume the required quantity of fuel to keep the temperature above 800° Fahr. in the various chambers is supplied through hollow fire-bars, G, which come to the front. Additional air can be supplied through the ashpit door, F, and between the bars if necessary. The air passing through the hollow fire-bars is delivered into the air casing, D, and from thence, at each side of the furnace casing, it is admitted over the fire by the square openings, E, at a high temperature. It becomes evenly mixed with the escaping gases and hydrocarbons rising unconsumed from the fuel, and is drawn *downwards* through the incandescent fuel underneath the inverted fire-bridge, and thoroughly converted into carbonic acid at a high temperature. This is admitted by the dampers, H, into the annular flues, I, *fig.* 2451, having rectangular openings, and evenly distributed through the chambers and delivered out, having passed through the peat into the annular flue, J, and thence to the exit flue, K, where it may be further utilised by passing in horizontal flues under the drying sheds to the stack, which will serve for several sets of carbonisers. The carbonising chambers are in sections or rings of cast iron bolted together, 6 feet in diameter, and of a total internal length of 12 feet. There is an air space of 3 inches all round, and the whole may be surmounted by brickwork. A hopper, marked 7, surrounds the chamber top, and a bell, 6, opens and closes it in a similar way to a blast furnace. When the hopper is filled with peat the bell is lowered and the peat is admitted, but it is immediately closed, the lever, J, to which it is suspended, having at its other end, attached by rods, a sliding damper closing the escape orifice, K. By this arrangement the admission of free oxygen is prevented. The chamber can be charged at all times, and with the sliding door or false bottom, M, below, the finished charcoal is instantly dropped into the cooling chamber, O. It is calculated that the output from four chambers would be at the rate of 16 tons per week. The refuse or waste peat is the fuel principally used, and for which the grate surface is necessarily large. The only condition necessary to its proper working is, that it shall be well banked up against the fire-bridge, to prevent air passing beneath it. The amount of heat can be nicely regulated, and the whole is under perfect control, while the process in each chamber can be hastened or retarded at will, or any one chamber worked without the others. The whole of the heat given off from the fuel is utilised at the lowest possible cost of labour, wear, and tear.

'To make the system more complete, and having in view the demand likely to arise for powdered charcoal, a disintegrator has been included in this patent, adaptable alike to this and other purposes.'

Mr. HALL has appended to his pages several very useful tables. The following, which deal with the more important elements, we desire to give permanence to in these pages:—

COMPOSITION OF PEAT. *Ultimate Elements of Peat.*

Description and Locality	Carbon	Hydrogen	Oxygen	Nitrogen	Authority	Products of the Distillation of Peat
Surface peat—Philipstown[1]	58·694	6·971	32·883	1·4514	Drs. KANE and SULLIVAN, reported in the *Dublin Journal of Industrial Progress*	Potassa.
Dense peat "	59·476	6·097	32·546	·8806		Soda.
Surface peat—Bog of Allen	59·920	6·614	32·207	1·2588		Lime.
Dense peat "	61·022	5·771	32·404	·8070		Magnesia.
Surface peat—Twickneham	60·102	6·723	31·288	1·8866		Alumina.
" Shannon	60·038	5·870	33·152	·9546		Sesquioxide of iron.
Dense peat "	61·247	5·616	31·446	1·6934	—	Phosphoric acid, sulphuric acid, hydrochloric acid.
Various samples of dried peat	60·0	6·0	33·0	1·0	REGNAULT, MULDER, KANE, SULLIVAN, RONALDS	Silica, in compounds decomposable by acids.
Peat from Westmeath	61·040	6·670	30·450		—	Sand and silicates undecomposable by acids.
" Clare	56·630	6·300	34·440		KANE, RONALDS	Carbonic acid.
" Kildare	51·000	6·850	39·330		WOSKRESSENSKY	Sulphate of ammonia.
" Tuam	57·307	5·615	35·049	2·067	—	Acetate of lime.
" Tuam	55·800	5·821	29·669	2·300	—	Pyroxylic spirit.
" Tuam	59·662	5·502	28·414	1·716	—	Naphtha.
" Eastern Russia	50·096	3·788	41·046		—	Heavy and fluid oils, paraffin, &c.
Average quality of peat	·464	·044	·248			
Condensed peat	47·2	4·0	33·0		Professor JOHNSON	—

[1] Samples dried previous to analyses at 220° Fahr.

Heating Power by THOMSON'S *Instrument.*

Samples of Dense Peat	Specific Gravity	Weight per cub. ft.	Lbs. of Water at 212° Fahr. converted into Steam per lb. of Peat consumed	Lbs. of Water at 212° Fahr. converted into Steam per cub. ft. of Dense Peat	Authority
Locality: Mountrath—Dense peat No. 1	0·663	41·34	6·03	249·57	Prof. GALLOWAY. No. 1 light upper fibrous portion of bog.
Queen's County " No. 2	1·006	62·60	5·50	343·74	No. 2 from middle of bog.
" " " No. 3	1·172	73·31	6·23	454·07	No. 3 from lower part of bog.

Heating Power of Peat and Charcoal.

District	Lbs. of Lead reduced per lb. of Peat	Lbs. of Water heated from 32° to 212° by 1 lb. of Peat	Authority
PEAT.			
Peat from Troyes . . .	8·0	18·1	BERTHIER.
" Ham . . .	12·3	27·9	"
" Passy . . .	13·0	29·2	"
" Framont . . .	15·4	34·9	"
" Ischoux . . .	15·3	34·6	"
" Konigsbrunn . .	14·3	32·4	"
" Bog of Allen . .	27·7	62·7	GRIFFITHS.
" " " . .	25·0	56·6	
Among 24 kinds from the Hartz Mountains the worst gave .	11·9	26·9	WINKLER.
The best gave	18·9	42·6	"
PEAT CHARCOAL.			
Peat charcoal from the Seine .	17·7	40·6	BERTHIER.
" Ham .	18·4	41·7	"
" Essone .	22·4	50·7	"
" Framont .	26·0	58·9	"

Total heat in 1 lb. peat; air used for combustion:—

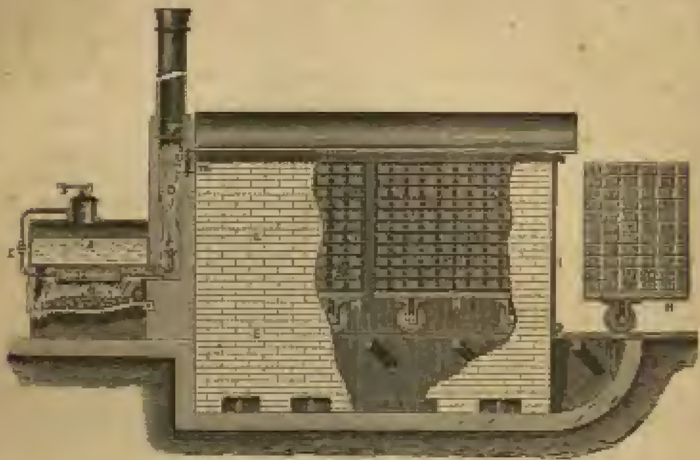
	Units	In Lbs.	In Cub. Ft.	
Peat artificially dried	8,736	15·370	202	BOX 'On Heat.'
Peat, ordinary state, containing 20 per cent. moisture	7,151	12·4	163	

Another process for charring peat, which has been tried in this country under the auspices of the DUKE OF SUTHERLAND, is deserving of attention. The process was devised by Mr. JOSHUA KIDD, of New York, and patented in this country by Mr. ARTHUR BARFF. The principle of this invention is to carbonise at the lowest possible temperature, and thus retain as far as practicable the volatile matters of the peat. The use of retorts is avoided, on the ground that all the heat employed to warm the material of the retort is wasted, and it is considered more economical and efficacious to direct the heat from a furnace, aided by superheated steam, straight into a chamber containing the peat to be carbonised. The chamber is thus practically a large retort heated from within. Thus is produced a charred peat rich in hydrocarbons, which on heating gives off gas of good illuminating power, and leaves a charcoal free from sulphur and phosphorus, and therefore well adapted for metallurgical operations.

The accompanying illustration, *fig.* 2402, shows the main features of Mr. KIDD's arrangement. It is a sectional view of a single chamber, which contains trucks laden with peat. The furnace is shown at B, with a boiler, A, above, whence the steam issues to a superheater, *c*, and then through steam jets, *b*, so as to force all products of combustion through D, the uptake, into the drying room at M. Here the heated

atmosphere, which of course contains no free oxygen, acts upon the peat packed on gratings mounted like trucks on wheels, and running on rails to facilitate removal.

2452



Two chambers are placed side by side, so that the heated vapours may flow from one to another through the openings, *l*, *l*, *l*, and so be thoroughly utilised. An iron door, I, at the hinder part of the chamber, affords space for the ingress and withdrawal of the trucks; the door is of course closed and luted up while the operation is being conducted. Starting with a cold room, the fire is lighted in the furnace, and the natural draught through the flue is employed to raise the heat, the damper, *y'*, being open and *y* closed. As soon as the steam gets up sufficiently, the damper, *y*, is opened, so as to set up a communication with the drying or carbonising chamber, and *y'* is closed. H H represent the racks for the peat, and *x x* the peat in them. The heat in the chamber soon rises to 300°, and there is no difficulty in keeping it between 300° and 400°, a temperature which is quite high enough to produce a good peat charcoal, containing a considerable amount of volatile hydro-carbons. The fuel employed is peat air-dried, and the expense of production is not high. A set of chambers for producing twenty tons of charred peat per week costs about 400*l*., and the actual working expenses in Sutherlandshire for preparing this quantity from hand-cut unpulped peat at the moss, partly air-dried, are as follows:—

40 tons peat, at say 3*s*. per ton	£6	0	0
13½ tons dried peat as fuel, at 4*s*. 6*d*. per ton . . .	3	0	9
Labour: two men at 15*s*. per week, and two boys at 10*s*. .	2	10	0
Producing 20 tons charcoal for	£11	10	9

Or about 11*s*. 6*d*. per ton. Each chamber is here reckoned as holding four tons of partly-dried peat, or half that weight of charred peat. A group of four chambers worked by two furnaces would turn out ten charges, and produce twenty tons of charcoal peat per week from forty tons of peat sufficiently dried to be stacked in the trucks. The trucks actually employed were 12 ft. by 8 ft. by 2½ ft., and the chambers of a proportionate size.

From the peat thus prepared may be distilled a gas of high illuminating power, in the proportion of 6,000 ft. to the ton, a tarry oil to the extent of 32½ gallons to the ton, and 12½ gallons per ton of water containing acetic acid. In an experiment tried at Gillespie, a hundredweight of charred peat gave off in twenty minutes 100 ft. of gas, with an illuminating power of seven candles. In another quarter of an hour the quantity of gas reached 150 ft., and the light was equal to thirteen candles. In one hour from the time of starting, the total volume of gas was 275 ft.

PENCILS, COPYING. M. Ch. Viedt says, in the *Bulletin of the Chemical Society of Paris*, for June 1875, that pencils which give traces capable of being copied like those of copying inks, are made from graphite ground up in water to a

fine paste, of finely powdered kaolin, and of a highly concentrated solution of an aniline violet blue soluble in water.

PEPPER, BLACK. The water and ash in peppers have been determined to be as follows:—

Description	Water dried at 100°	Pepper dried at 100°		Pepper as sold. Total Ash
		Total Ash	Soluble Ash	
	Per cent.	Per cent.	Per cent.	Per cent.
Penang	9·631	4·189	2·212	3·843
Tellicherry	12·909	5·770	3·350	5·346
Sumatra	10·103	4·316	2·626	3·334
Malabar	10·548	5·195	3·453	4·674
Trang	11·464	4·775	2·538	4·211

An analysis of the ash of a sample of Tellicherry pepper gave the following percentages:—

Potash	24·350
Soda	3·220
Magnesia	13·000
Lime	11·600
Iron	0·300
Phosphoric acid	8·470
Sulphuric acid	9·613
Chlorine	7·570
Carbonic acid	14·000
Sand	6·630

Description	Nitrates and Nitrites in Pepper calculated as Nitric Acid	Alcoholic Extract from 100 Grams dried at 100°	Aqueous Extract from 100 Grams dried at 100°
Penang	0·04470	7·050	18·335
Malabar	0·03858	6·375	20·375
Tellicherry	0·08860	7·896	16·500
Sumatra	0·06560	6·450	17·500
Trang	0·11870	6·300	18·175

The alcoholic extract consists almost entirely of piperine and resin, and is a fair index of the value of a pepper.

The aqueous extract contains extractive and colouring matter, soluble salts, gum, starch, and small quantities of piperine and resin.—A. W. Blyth, *Pharm. Journ. Trans.* (3); and *Journal of the Chemical Society.*

'PERLES DE CONQUE.' The name given in commerce to the conch pearls. See Pearls, Conch.

PERNAMBUCO WOOD. Used for colouring wine. See Wines.

PERSIAN RED. M. Prinvault communicates to the Industrial Society of Rouen a process for obtaining a fine scarlet of the shade known as Persian red, from chromate of lead.

If chromate of lead is digested with a cold solution of 1 part of the neutral chromate of lead in 50 parts of water, so that two equivalents of the former may react with one of the latter compounds, there is obtained in two days a crystalline precipitate of basic chromate of lead. If the supernatant liquid is boiled, it evolves carbonic acid, since bicarbonate of potassa is present, and is converted into a solution of potash, which decomposes a part of the red precipitate, so that it takes a violet-red colour, whilst the liquid turns yellow. The precipitate is too dull to be of any value. If it is washed with water, and treated with 4 per cent. of its weight of dilute sulphuric acid (1 in 100), adding the acid slowly and stirring, and then neutralising with a dilute solution of soda, there is formed a mixture of sulphate and of basic chromate of lead, the colour passing into a fiery vermilion. The quantity obtained is about equal to the carbonate of lead employed. According to M. Prinvault, nitric or acetic acid may be used instead of sulphuric, but not hydrochloric. The proportions he employs are 25 grams neutral carbonate of lead, with 10 grams neutral chromate of potassa. He digests two days in the cold, boils for half an hour, filters,

washes the precipitate, and treats it with 1 gram of sulphuric acid diluted with 100 grams of water. The new red cannot be fixed with albumen, on account of its crystalline texture. It may, however, be possible to convert chrome orange into Persian red upon the fibre.

PETROLEUM. (Vol. iii. p. 544); PARAFFIN (vol. iii. p. 502); NAPHTHAS (vol. iii. p. 386, 389–90, 397). The following is from a paper on petroleum oil read before the American Chemical Society, and printed in the *American Chemist* for June 1876. A general summary of the results appears to be all that is necessary.

'(1) The naphthas distilled were comparatively heavy, 60° to 64° B., technically known as *benzines*. (2) The removal of about 10 per cent. of these naphthas from an average unsafe oil, raised the flashing point 2°·27, and the burning point 1°·3 Fahr. for each per cent. removed; the addition of the same proportion of naphtha of equal specific gravity lowered the flashing point in very nearly the same ratio. (3) A varying amount of a light naphtha, above 70° B., could not be added to even a very high-grade oil without making it conspicuously bad, while as much as 10 per cent. of a heavier naphtha—benzine—of 65° B., could be added to an oil of little above 100° Fahr. flashing test, and make it no worse than much of the oil now in the market. (4) When a small amount of naphtha of above 70° B. is added to a good oil, the flashing point is lowered much more rapidly than the burning point; if the oil is of very high grade and the naphtha moderately heavy, 65° B., the burning point of the oil is lowered almost as rapidly as the flashing point; while the addition of a naphtha of 65° B. to a moderately good oil, flashing at 104° Fahr., lowers the flashing point 35 to 40 per cent. more rapidly than the burning point. (5) The burning point is not a reliable test of the safety of an oil, since oils, when spilled, will ignite instantly on the approach of a flame, when heated a degree or two above their flashing point, even although the burning point is 10° or 20° Fahr. higher. (6) Experiments show that an oil flashing at 86° and burning at 107° Fahr., can be made to flash at 100° Fahr. by removing 6 or 7 per cent. by distillation. This corresponds nearly with the estimate furnished to Mr. CORNWALL by Mr. H. N. ROGERS, that average petroleum yielding 76 per cent. of 100° Fahr. "fire test"—burning test—oil, would probably yield 69 per cent of 100° "flash" oil; in other words, 8 per cent. of the 100° "fire test" oil would have to be removed to make a 100° "flash" oil. The average flashing point of eight oils given in Dr. CHANDLER's report as burning at 110° Fahr. was 60°.'

The following is the latest return made of the progress of the petroleum industry:—

New wells completed in 1876	2,290	
Daily average product of new wells	12½	barrels
Number of producing wells to the end of December .	6,000	
Daily average product of all wells	5, 6, 10	"
Production for the year 1876	8,968,906	"
Stock on hand at the end of year	2,551,199	"

STOWELL's *Petroleum Reporter.*

ONTARIO.—Surface oil was known to exist in the southern part of the township of Enniskillen from the time of the first settlement of the western part of Ontario.

At present (1876) there are about 350 wells capable of producing petroleum, but, owing to the dulness of the market, only about 200 of these are in operation. At one time about 500 small steam-engines for boring and pumping were on the ground, but this number is now reduced to between 200 and 300. The oil-wells in Ontario have all been bored by the ordinary percussion drill. A small proportion of the oil is distilled at Petrolia, but the greater part is refined in London, about 50 miles to the eastward. Here there are fifteen refineries, of a total capacity of 12,000 to 15,000 barrels per week. The total value of the plant, &c., employed in the production of the oil is valued at about $750,000, and of that used in the refining processes at about $550,000, although at one time both were considerably greater. There has also been a falling off in the number of men employed in both processes, the number now being about 500 engaged in connection with the producing, and 300 with refining. The amount of oil sent from Enniskillen region previous to January 31, 1862, was 11,775 barrels. For the year ending January 31, 1863, the quantity was 82,814 barrels, after which time the yield gradually increased for ten years. The following are the quantities refined in Ontario for the last five years:—

Year ending June 30, 1871	269,395	barrels of 40 gallons
" " 1872	308,100	" "
" " 1873	365,052	" "
" " 1874	168,807	" "
" " 1875 . . (about)	210,000	" "

Latterly, the greater part of the oil has been consumed within the Dominion, only a comparatively small proportion being exported.

In former years, and when petroleum commanded much higher prices than at present, it was sought for by boring in the rock, and obtained in greater or less quantities near Wequamikong, on the Grand Manitoulin Island, in Lake Huron, at Tilsonburg and Bothwell, in the western peninsula of Ontario, and around Gaspé Bay, in the province of Quebec. Traces of it have been found in various other parts of Ontario and Quebec; also in Cape Breton, and at Port au Port, on the west coast of Newfoundland. The petroleum of Manitoulin Island comes from limestones of the Trenton formation, that of Gaspé, Tilsonburg, Bothwell, and Enniskillen, as well as the great natural outflow of the Athabaska River is derived, in each case, from rocks belonging to the *Devonian System*.

The occurrence of petroleum on the Athabaska was recorded by Sir ALEXANDER MCKENZIE in 1789, and again by Sir JOHN RICHARDSON in 1851. The first-named author states, alluding to the forks of the Athabaska or Elk River, that 'at about 24 miles from the forks are some bituminous fountains into which a pole 20 feet long can be inserted without the least resistance. The bitumen is in a fluid state; heated it emits a smell like that of sea-coal.' And Sir JOHN RICHARDSON says: 'The whole country for many miles is so full of bitumen that it flows readily into a pit dug a few feet below the surface.'—*Geological Survey of Canada.*

ROUMANIA.—The advantages claimed for petroleum, as a steam fuel are, cheapness as a generator, economy of space for storage, and greater simplicity in the arrangement of the furnace. It is needless to say that each of these propositions is combated by some scientific man on theoretical grounds; but, assuming that the experiments have proved as satisfactory as is stated, it does not necessarily follow that petroleum could supersede coal in a country where the latter mineral is plentiful and the former article scarce. In a country like Turkey, however, where the coal measures are undeveloped, and steam fuel has to be imported, the value of a large supply of native petroleum is of the highest possible kind.

'There are about 7,000 flour-mills in Roumania, only 30 of which are worked by steam, the remainder being worked by water, wind, horses, and oxen. There are also 1,637 distilleries, 608 saw-mills, only a few of which are worked by steam; 72 breweries, 145 soap and candle manufactories, besides oil-mills, &c., most of which require power in the different manufacturing processes. To such a country the possession of an abundant supply of petroleum is obviously of the greatest importance, and the increase of wealth which would result from the substitution of steam for water and wind, as motors in Roumania, would be difficult to calculate. The advantages claimed for water as a motor are, in most cases, more apparent than real. The situations are few where a steady supply of water can be relied upon during the whole year, undisturbed by either floods or droughts, and they are fewer still where an extraordinary run of water can be carried off without interfering with the driving machinery. If, therefore, the uncertainty of being able to work—through the operation of the two causes named—be considered, and the average expense of sustaining the banks of streams, and maintaining the walls of reservoirs and sluices, be taken into account, in comparison with cheap steam, which can be generated by the combustion of the native petroleum, there cannot be a doubt that steam so produced will be the more economical of the two.'—*Consular Report*, 1876.

Recent trials have certainly proved that the mineral oils can be burnt advantageously in boilers for stationary, marine, and locomotive engines, as well as in the reduction of iron ore, and for stoves in family use. Efforts have been unceasingly made to perfect the arrangement for burning, and for the safety of the fuel-oil, and one improved plan is suggested which may lead to important results. If a jet of steam be allowed to enter a tube, the other end being open to the atmosphere, a current of air will be drawn through and projected with the steam on the oil at a pressure corresponding to that of the former, making a powerful air as well as steam blast, and the furnace would act on the same principle as a cupola-furnace for melting iron. This would appear to be much more economical than the simple steam-jet for burning petroleum, as the oxygen of the air forced in with the steam would insure rapid and perfect combustion.

To forge iron, smelt ores, and melt glass, all that is necessary is to superheat the steam; but for ordinary furnaces the latter is not necessary. Although petroleum burned without steam blast has not yet been sufficiently economical, experiments now being made by WIESNEGG and DEVILLE, of Paris, for furnaces of stationary and locomotive boilers, seem to point to an early solution of this difficulty.

It has been stated, we fear with a want of exactness, that by various experiments it has been found that the maximum power of coal is the evaporation of eleven times its weight of water, while 1 lb. of crude petroleum, at 46° Baumé, will convert 24 lb.

of water into steam, being about 2$\frac{31}{100}$ths in proportion to coal. The average of the heat-producing power of petroleum does not fall far below this average, but that of coal is often only five to six times its weight of water. In relation to petroleum in ordinary furnaces and stoves, the *Oil Trade Review* advocates petroleum oil-stoves as much more economical than those of coal, and expects soon to see them made so as to be portable to any part of a house like a lantern. Such stoves are being constantly improved, and are gradually coming into use.

One of the newly-discovered uses for petroleum is the prevention of scale in boilers. The usual mode of applying it to a 50 horse-power boiler is ½ gallon of petroleum with 6 to 10 lb. of sal-soda. The boiler is to be cleaned before the first application, and the dose should be continued every two weeks. An eminent chemist states that a scale of 1-16th inch in thickness on a boiler will require 15 per cent. more fuel; ¼ inch requires 60 per cent. additional; ½ inch 150 per cent. more than if the boiler were clean.

Great efforts have of late years been made to produce a cheaper illuminating gas from petroleum. Should this succeed, and also the experiments on furnaces and stoves, the idea which has been advanced of heating, lighting, and furnishing power to cities by squares from various stations, may yet be accomplished in the future. We cannot here enlarge on this subject; but we must in passing refer to the petroleum gas apparatus erected by J. F. G. Kromschroeder at Great Marlow, in Buckinghamshire. This inventor is probably the first who has lighted a town without the use of any coal—a very important object in England at present, and indeed anywhere. He states that he has already made the gas at cost much less than the London public works, and expects to still reduce considerably the present price. He does not claim that this will supersede large coal gas-works for great cities, but that it can be usefully and very cheaply adapted to small towns using about 1,000,000 cubic feet per annum.

Although petroleum oils and their products rather repress than produce spontaneous combustion, it is not to be denied that they have caused numerous fires, some very disastrous, but these have generally arisen from the carelessness or ignorance of those using the oils, and at times by the evolution of inflammatory gas, which became ignited through accident. See next articles.

PETROLEUM OILS, THE COMBUSTION OF. The chief object of this article is to direct attention to the dangers incidental to the transport and storing of petroleum, and to the means of extinguishing fire when it takes place. In commerce petroleum is recognised as of two kinds: one is light, of a greenish brown colour, varying in density from 0·800 to 0·815; the other is heavy, of a deeper colour, and of a density varying from 0·840 to 0·900. As petroleum is not commonly fit to be used in its crude state, fractional distillation is resorted to. The products of such distillation are:—1. The essential oil of petroleum, colourless and extremely fluid. It volatilises quickly and produces very inflammable vapour. The density is from 0·700 to 0·750. 2. Photogene or burning oil, usually of a yellow colour; it gives off inflammable vapour at 98°·6 Fahr. (37° C.); specific gravity from 0·800 to 0·815. 3. Lubricating oil, of a density varying from 0·840 to 0·900. 4. Paraffin and tar, employed for the same purposes as asphalte.

Petroleum in the crude state, or the essential oil of petroleum, spread in a sheet, either on water or on the ground, and exposed to the open air, takes fire at a temperature above 32° Fahr. on the application of a lighted match. The presence of flame, however, is necessary for its ignition at a temperature below 68° Fahr. (20° C.). A lump of coal at a cherry red, or of iron at a dull red heat equal to from 1,112° to 1,292° Fahr. (600° to 700° C.), plunged into the liquid does not ignite it. When placed in an open vessel and suddenly raised to a temperature of from 572° to 662° Fahr. (300° to 350° C.) by the immersion of a piece of red-hot iron, the liquids give off intensely white vapours which explode like gunpowder by contact with flame. Two barrels were filled, one with crude oil, the other with the essential oil, to within 1 inch (2 to 3 centimètres) of the bung-hole; on setting fire to the contents they burned with wavering flames about 3 inches high (6 to 7 centimètres), without any explosion.

Refined burning-oil is not considered up to standard unless it requires for inflaming a temperature, at the lowest, of 98°·6 Fahr. (37° C.); that is to say, the temperature of the small portion in contact with the flame. Some imagine, however, that it is not the oil in the liquid state which burns, but its vapours. This conclusion is negatived by a lighted night-light floating on the surface of refined oil at a low temperature; a few seconds afterwards flame is communicated to the oil immediately surrounding the night-light, and extends gradually over the whole surface of the oil. M. Pellet's experiments on the qualities of petroleum show the relation of density to the temperature at which it inflames. Annexed are the densities for various temperatures:—

Density	Temperature of Inflammation	
0·655	5·8	21
0·700	2·2	19
0·740	+ 59·0	+ 15
0·750	62·6	17
0·760	95	35
0·775	113	45
0·783	122	50
0·792	167	75
0·805	194	90
0·822	230	110
0·802 (crude petroleum)	59	15

M. PELLER shows that, as there cannot be explosion without a space for vapour (mingled with air) in the recipients above the petroleum, it would render the storage of petroleum safe if it were kept in vessels immersed overhead in water, communication being made between the water and the oil-vessel at the bottom of the latter. The petroleum being drawn off from the top, the water would flow in below, and thus always keep the petroleum close up against the top of the containing vessel, and prevent the possibility of an accumulation of vapour.

A stratum of crude petroleum 3·5 inches thick (9 centimètres), weighing 176 lb. (80 kilograms), was kept at rest on the surface of the sea, within a floating inclosure 40 inches square (1 mètre) and 8 inches high (0·2 mètre). The weather being calm, and the temperature of the air 59° Fahr. (15° C.), this quantity was burned in 35 minutes, and raised a column of flame 8 feet 2 inches high (2·5 mètres). Combustion thus proceeded at the rate of 5 lb. per minute (2·28 kilograms), consuming a thickness of 0·106 inch (2·7 millimètres) in the same time. When the layer of petroleum was reduced by combustion to a thickness of from 0·20 to 0·24 inch (5 to 6 millimètres), the sea-water commenced to boil, the agitation caused by which redoubled the energy of the combustion and raised the flame to a height of 19 feet 8 inches (6 mètres). The residue of the combustion consisted of a sheet of black fatty matter 0·08 inch (2 millimètres) thick.

It is remarked that the slightest agitation of the surface of the oil very much augments the development of flame. A small piece of wood thrown into burning petroleum, on rising liberates vapour and causes an explosion like that of gunpowder. M. PELLER describes in detail the process of burning experimentally barrels of petroleum under varying circumstances. He then points out how essential it is for safety that petroleum in warehouses should be below the ground level, and that ships in port should be surrounded by floating inclosures, so that in both instances the oil, in the event of a fire, may be prevented from spreading. He next proceeds to the consideration of the volatility of petroleum and its products, to ascertain which each kind of petroleum was exposed to the open air in glass vessels exactly gauged, presenting an evaporative surface of 4·65 square inches (30 square centimètres), with a volume of 12·8 cubic inches (210 cubic centimètres), forming a column 2·74 inches high (7 centimètres). From the observed depressions of level caused by evaporation, the loss per square yard of surface per twenty-four hours was deduced as follows :—

0·64 gallons per square yard	(3·5 litres per square mètre)	refined petroleum.
1·66 " "	(9 " ")	crude "
3·31 " "	(18 " ")	alcohol.
7·18 " "	(39 " ")	essential oil.

The manner in which fire by petroleum may be prevented in warehouses and on quays, and the best means for securing its safe storage, may be briefly stated as follows :—

1. Storing barrels or cases in warehouses of one story only built of incombustible materials.

2. Transferring the oil into metallic tanks.

3. Making a large tank in masonry, filling it with water, and plunging into it, mouth downwards, a vessel like a gas-holder, containing the petroleum, which is to float on the water within the inverted vessel.

4. Attaching weights to the ordinary barrels and sinking them in water.

The author points out that if a ship laden with petroleum takes fire in a crowded port, it is worse than useless, so far as the other vessels are concerned, to scuttle her, because the water rushing in displaces the petroleum, and thus causes it to float about over the surface of the water instead of being confined to the burning ship.

The paper concludes with two tables, one of which shows the relative proportion of the various products obtained by fractional distillation from different petroleums, and is given on the next page.

The other table, based on the experiments of M. Henri Saint-Claire Deville, gives the specific gravities, the co-efficient of dilatation, and the weight of water that can be evaporated by each of forty-one different mineral oils. The specific gravity varies from 0·786 for petroleum of Parma to 1·044 for the heavy oil of the Parisian Gas Company. The co-efficient of dilatation ranges from 0·000641 in the case of petroleum of Hanover (Wilze) to 0·001 in the case of the Parma petroleum and of West Canada; while the power of evaporating water lies between 12·240 times the weight of the oil for the crude petroleum of the schists of Vagnas (Ardèche) to 15·364 times the weight of the combustible for the oil of Schwabwiller (Bas-Rhin):—

Products of Distillation	Oil from Pennsylvania (density 0·802)	Oil from Canada (density 0·835)	Oil from United States Province unknown (density 0·830)
Essence of petroleum (D. = 0·736) .	14·7	12·5	4·3
Lighting oils (D. = 0·820) . . .	41·0	35·8	44·2
Lubricating oils	39·4	43·7	45·7
Paraffin	2·0	3·0	2·7
Residue	2·1	3·2	2·2
Loss	0·8	1·8	0·9
Totals	100·0	100·0	100·0

PETROLEUM AS FUEL. See Mineral Oils Industry in this vol.; Naphtha, its Varieties, vol. iii. p. 387, &c.; Petroleum, vol. iii. p. 544. Numerous attempts have been made from time to time to employ the mineral oils for the production of heat. Some important information on this subject will be found in the 'Report of the Royal Commission on the Quantity of Coal in the United Kingdom,' and some communications have been made to the Society of Arts by Dr. Paul and others. We have now to mention a few more recent experiments in burning petroleum.

One method, which has been found fairly successful in practice on the Continent, is that of spreading a bed of infusorial earth, 'kieselguhr,' on the bars of the furnace, and spreading the petroleum upon this.

The most promising of recent inventions is that for which a patent has been obtained by M. De Bengue, of Paris, and which consists in the application and use of air-gas and of petroleum in a finely-divided condition introduced by a blast of air or steam, or both, for combustion in furnaces or for other heating purposes; also the use, supply, or introduction of wood, charcoal, peat, or other fossil fuel in combination with air-gas and petroleum. The air-gas is applied by forcing it through tubes with holes or jets in them, the tubes lying parallel to and between, but underneath, the furnace bars, over which may be placed a stratum or layer of asbestos or infusorial earth to absorb the petroleum. The petroleum (preferably the heavy lubricating oil of commerce) is applied in a finely-divided condition by introducing it in the form of minute globules or spray by and together with a blast of air or steam, or both, passing through compound tuyeres or nozzles directed through the front or sides of the furnace and above the level or heights of the bars. These compound tuyeres are each composed of a nozzle tapering endways, and having applied thereto a blast-pipe for air or steam, or both, provided with a tapering end or second nozzle introduced within the first, to which latter there is also fitted a third tapering nozzle for the petroleum supply directed transversely with regard to the length of the first. The nozzles first mentioned as forming a portion of the compound nozzle may also be provided with holes for the admission of additional air to be carried in with the blast. If air or steam, or air with steam, be forced through the blast-pipe, it will suck up or draw and convey petroleum through the third nozzle, and the petroleum will be reduced to minute globules or spray, or be vaporised, and, with the blast and the additional air, when the nozzle is provided with holes, will be discharged into the furnace. The petroleum to be so treated is or may be the residuum of the petroleum which has been already employed in the production of the air-gas.

The Substitution of Petroleum Gas for Coal Gas, G. D. Patton's Process.—The advantages of petroleum gas over coal gas are stated to be great both in the economy of its production and of its burning; it is safe under any circumstances that coal-gas is, and in one respect is safer—it requires a greater and more complete admixture of air before it explodes. Mr. Patton's process of production appears to be simple enough, and, he states, carried out with great satisfaction and small expense. The point to be observed in making gas from petroleum is to obtain the exact heat neces-

sary to effect a decomposition of the petroleum (naphtha, Mr. PATTOX uses, as being the cheapest), as too much heat destroys the illuminating power by depositing a large quantity of carbon. Mr. PATTOX secures just the proper degree of heat by a simple arrangement for the *gradual* heating of a small stream of oil through the various liquid and vapour states up to that point in which it becomes a fixed gas, and is then immediately passed out towards the gasometer in a condition ready for use. The petroleum gas does not give a much more brilliant light than a coal gas of 10 candles, but 1 foot of the petroleum will give as much light as 5 feet of the coal-gas. It does not, like coal-gas, deteriorate in illuminating power with extreme cold or pressure, and for this reason it is recommended for the lighting of travelling cars, &c. It would also be useful to improve the quality of an inferior coal-gas: 1,000 feet of petroleum gas added to 12,000 feet of coal gas (illuminating power 11½ candles) would make 13,000 feet of gas with illuminating power equal to 16 candles. If the supply of air is insufficient, the combustion will be imperfect, and the result will be that the very elements which should give light will pass off in the form of smoke. The best mode for supplying the necessary quantity of air is the use of burners specially adapted to this gas, and from which it is ejected at the rate of one foot an hour, in sheets so thin that they receive air enough for perfect combustion from natural draught, just as coal-gas or a candle flame does. Petroleum gas can be manufactured on a small scale to almost as good an advantage as on a large one, and thus can be brought within the reach of the smallest communities, or even of single residences or factories.

PETROLEUM DESTROYED BY LIGHTNING. In STOWELL'S *Petroleum Reporter* we find that the destruction of oil by lightning has been large during the year 1876 to the end of July, amounting to 242,412 barrels from January 1 to July 31 of this year, or rather from April to August. There were no fires from this cause in January, February, or March; two occurred in April, none in May, four in June, and five in July. It is scarcely necessary to say that the oil destroyed was in closed-top iron tanks, and the lightning striking these, exploded the gas that collected in the space above the oil, scattered the oil, and set it on fire, and often communicated to other tanks in the immediate vicinity. The theory most commonly received in the oil regions of the cause of lightning 'strikes' is, that the gas which, it is well known, is continually escaping from the oil in these tanks, rises to some distance above them, acts as a conductor, and the damage is done. One peculiar feature in the history of these accidents is, so far as we have been able to learn, no iron-top tank has been struck, but in every case wooden-top ones. Special inquiries have been made on this point. So far, attempts to protect tanks with lightning rods have been failures; at Dilks station a number of rods, supposed to be ample protection, were placed about the tanks, but they were no protection against this summer's lightning. It may be interesting to those not acquainted with the oil business to state that in case of losses occurring in this way all the oil in the pipe line to which the tanks belong is assessed *pro rata* for the loss; that is, the law of 'general average,' so well known in marine law, is applied in this case.

Petroleum imported in 1875 and 1876, according to the Annual Statement of the Trade of the United Kingdom.

UNREFINED.				
	1875		1876	
	Tons	Value	Tons	Value
From United States of America .	1,379	£9,548	1,458	£14,039
,, other Countries . .	25	248	428	1,913
Total . . .	1,404	9,796	1,886	15,952
REFINED.				
	Gallons	Value	Gallons	Value
From United States of America .	18,951,671	£760,940	24,188,268	£1,374,121
,, British North America .	—	—	435,129	35,500
,, other Countries . .	105,660	4,505	102,505	6,713
Total . . .	19,057,131	765,445	24,725,905	1,416,334

PETROLCENE. A hydrocarbon, a product of the dry distillation of the tar, or residuary matter, from petroleum.

It sublimes over at the end of the distillation, accompanied by a thick resinous oil of about ·980 sp. gr. In its crude state this mixture of oil and petrocene is bright orange in colour, which rapidly becomes dark green on the surface by oxidation. From this petrocene is separated by lixiviation with benzine, and when thoroughly separated from the oil it is obtained as a yellowish-green crystalline, extremely light precipitate.

Petrocene fuses at 420° to 425° Fahr. Its sp. gr. is 1·2066. It is crystalline and dark olive in colour, not very hard, but brittle.

When petrocene is distilled in large quantities, it can be separated into a series of interesting and beautiful products. These promise to become useful in the arts, but they have not hitherto been applied in any way.—Dr. HERBERT W. C. TWEDDLE, 'Petrocene and its Products,' *Journal of the Franklin Institute*, September 1876. See VASELINE.

PETZITE. One of the names given to an ore of tellurium, with pyrites, siderites, and quartz found in North Carolina. See ALTAITE.

PHENOL COLOURING MATTER. See vol. iii. pp. 552, 553; PHENICIN, PHENOL, &c. M. C. LIEBERMANN communicated to the *Académie des Sciences* a paper on 'Colouring Matters obtained from Oxy-compounds and Nitrous Acid.' This paper is published in the *Comptes Rendus*.

Five grams of phenol were mixed with an equal volume of concentrated sulphuric acid, and kept very cool to prevent the formation of phenol-para-sulphuric acid. The acid was added, with agitation, in such proportions that the temperature rose slowly from 40° C. to 50° C. without rising higher. This was effected in about fifteen minutes. The solution was at first brown, and then it became a fine blue. During the process, especially towards the end, there was a faint disengagement of gas. On cooling, the solution was poured, with constant stirring, into a large quantity of cold water, filtered, concentrated by evaporation in a porcelain vessel, and dried. It can be dried at 130° C. without undergoing any change. It is a brown powder soluble in alcohol. In alkalies it dissolves with a royal blue colour. Its composition is $C^{18}H^{15}NO^{3}$.

Phenol in an acidulated aqueous solution, or in the form of a phenate, when exposed to electrolysis, gives rise at the positive pole to a brown body.

PHOSPHATE OF LIME. See PHOSPHATES, vol. iii. p. 553. Dr. SACC, of Neuchâtel, who has been engaged for many years in studying the phosphate of lime, appears to have formed some exaggerated notions of its powers. M. CLAUDE COLLAS, however, states in *Les Mondes*, March 11, 1875, that Dr. Sacc has found that it determines the putrid fermentation in animal matters, and the disintegration of dead vegetable matter. He has also applied it as a mordant in dyeing. The yarns or pieces are steeped in a solution of phosphate of lime in hydrochloric acid, diluted according to the judgment of the dyer, and then transferred to an alkaline dye-bath. Hydrated phosphate of lime precipitates colouring matters from their solutions, forming lakes.

Analysis of phosphate of lime from Ciply, in Belgium, by NIVOIT:

Water, Organic matter, Carbonic acid	25·55
Sand and clay	1·30
Phosphoric acid	20·35
Sulphuric acid	0·12
Chlorine	0·25
Fluor	0·18
Lime	51·60
Oxide of iron	0·90

A grey limestone from the same place, interspersed with small brown granules, gave—

Loss on ignition	31·00
Sand and clay	2·10
Phosphoric acid	11·13
Lime	54·00
Oxide of iron	1·16
Loss	0·67

—NIVOIT, *Centralblatt für Agrikultur-Chemie*, February 2, 1876.

A *Note on the Phosphates of the Laurentian and Cambrian Rocks of Canada* was communicated to the Geological Society by Principal DAWSON, of which the following is the abstract published:—

The author described the mode of occurrence of phosphatic deposits in various lo-

calities in Canada. Dark phosphatic nodules, containing fragments of *Lingula*, abound in the Chazy formation at Allumette Island, Grenville, Hawkesbury, and Lochiel. Similar nodules occur in the graptolite shales of the Quebec group at Point Levis, and in limestones and conglomerates of the Lower Potsdam at Rivière Ouelle, Kamouraska, and elsewhere on the Lower St. Lawrence; these deposits also contain small phosphatic tubes resembling *Serpulites*. The Acadian or Menevian group near St. John, New Brunswick, contains layers of calcareous sandstone, blackened with phosphatic matter, consisting of shells and fragments of *Lingula*. The author described the general character of the phosphatic nodules examined by him at Kamouraska, and gave the results of analyses made of others from various localities, which furnished from 36·38 to 55·65 per cent. of phosphate of lime. A tube from Rivière Ouelle gave 67·63 per cent. The author accepted Dr. Hunt's view of the coprolitic nature of the nodules, and inclined to extend this interpretation to the tubes. The animals producing the coprolites could not be thought to be vegetable feeders; and he remarked that the animals inhabiting the primordial seas employed phosphate of lime in the formation of their hard parts, as had been shown to be the case with *Lingula*, *Conularia*, and the Crustaceans. The shells of genus *Hyolithes* also contain a considerable portion of phosphate of lime. Hence the carnivorous animals of the Cambrian seas would probably produce phosphatic coprolites.

With regard to the Laurentian apatite deposits, the author stated that they, to a great extent, form beds interstratified with the other members of the series, chiefly in the upper part of the Lower Laurentian above the *Eozoon* limestones. The mineral often forms compact beds with little foreign matter, sometimes several feet thick, but varying in this respect. Thin layers of apatite sometimes occur in the lines of bedding of the rock. Occasionally disseminated crystals are found throughout thick beds of limestone, and even in beds of magnetite. The veins of apatite are found in irregular fissures; and as they are found principally in the same parts of the seams which contain the beds, the author regarded them as of secondary origin. The Laurentian apatite presents a perfectly crystalline texture, and the containing strata are highly metamorphosed. The author's arguments in favour of its organic origin are derived from the supposed organic origin of the iron ores of the Laurentian, from the existence of *Eozoon*, from the want of organic structure in the Silurian deposit described by Mr. D. C. Davies, and the presence of associated graphite in both cases, from the character of the Acadian linguliferous sandstone, which might by metamorphism furnish a pyroxenite rock with masses of apatite, like those of the Laurentian series, and from the prevalence of animals with phosphatic crusts in the Primordial age, and the probability that this occurred also in the Laurentian. The position of the phosphatic deposits above the horizon of *Eozoon* is also adduced by the author as adding probability to the existence of organic agencies at the time of their formation.

PHOSPHATIC MINERALS. Phosphatic Nodules (vol. iii. p. 554); Coprolites (vol. i. p. 948). Much additional information has been published since the appearance of the former articles. Dr. Augustus Voelcker has published in the *Journal of the Royal Agricultural Society* a new article, giving the composition of a considerable number of phosphatic minerals, and to that article and Dr. Voelcker's kindness we are indebted for much that follows.

In England the coprolite diggings are no longer confined to Cambridgeshire, Hertfordshire, and Suffolk; these phosphatic nodules are now found also in the adjoining counties.

Mr. J. J. Harris Teall, in his Sedgwick Prize Essay, gives the following localities:—

Potton, in Bedfordshire, in the Neocomian series, noticed by the Rev. P. B. Brodie in the *Geological Magazine*, vol. iii. p. 153. Mr. Teall gives the sections at Potton—

(1) Conglomerate of small pebbles	2 ft.
(2) Irregular alternating layers of red and yellow sand	6 „
(3) Nodule bed (phosphatic)	6 in.
(4) Light coloured sands	thickness unknown.

The sections on sandy heath being—

(1) Sands (slightly indurated)	3 ft.
(2) Coarse ferruginous sand, &c.	4 to 5 ft.
(3) Horizontally stratified sandstone with small pebbles	2 ft. 10 in.
(4) Nodule (phosphatic)	2 ft.

The phosphatic nodule bed is composed of nodules and pebbles in equal proportions, associated together in a matrix of ferruginous sand. The nodules consist of fossils and lumps of phosphatic matter, the former being the more numerous. Of these the following analyses by Dr. Voelcker were published in Mr. Brodie's paper:—

	I.	II.
Water of combination	5·17	5·67
Phosphoric acid[1]	22·30	15·12
Lime	32·73	26·69
Mg, Al and Fe	6·64	4·51
Carbonic acid[2]	3·06	2·18
Iron oxide	8·08	20·61
Silicious matter	21·93	25·22
	100·00	100·00
[1] Equal to *tricalcic phosphate*	48·51	32·76
[2] Equal to carbonate of lime	6·95	4·95

I. is an average sample of siftings.
II. the analysis of washed coprolites.

Wicken.—In the *Geological Magazine* (vol. iv. p. 309), Mr. Walker gives the following sections:—

Surface soil	1 ft. 6 in.
Layer of light-coloured coprolites	—
Sand (silt)	1 ft.
Layer of dark-coloured coprolites	9 in.
Silt	1 ft. 6 in.
Layer of dark-coloured coprolites	1 ft.
Kimmeridge clay	—

The phosphatic bed consists of nodules, pebbles, and shells imbedded in a sandy matrix, containing a considerable quantity of lime. The nodules are of two colours—light and dark. The former resemble those of Potton; the latter are characterised by a smooth exterior, and a smaller percentage of phosphate. The following localities are given by Mr. Teale in addition to those already given in vol. i. (Coprolites):—

Hunstanton Cliff, Norfolk.
Downham.
West Downham, 4 miles east of Downham.
Folkestone series.
Ely and at Streatham.
Haddenham, 1 mile west of Streatham.
Caxton and Gamlingay.
Brickhill, Ampthill and Millbrook.—At the latter place he gives the following section:—

(1) Red and yellow sands (false bedded)	8 to 10 ft.
(2) Phosphatic nodule bed containing a great number of Lydian stone pebbles. (See vol. iii. p. 149)	4 in.
(3) Yellow and white sand (Bedfordshire)	15 ft. to bottom of pit.

Leighton.—About a mile south of Leighton, in a railway cutting, a dark clay with coprolites is seen to be capped by sands, and a mile further a true gault occurs, also containing coprolites.

Cheddington.—About half a mile from Cheddington station. Numerous other workings are found in the neighbourhood, and they extend in a linear direction from Aylesbury through Cheddington.

In addition to the analyses of English coprolites published in the article 'Coprolites,' we have the following analyses by Dr. Voelcker:—

General Composition of Cambridge Coprolites.

	No. 1	No. 2	No. 3	No. 4
Moisture	2·30	3·70	1·19	1·13
Water of combination, &c.	1·50		1·99	2·87
Phosphoric acid	26·05	29·14	25·80	26·15
Lime	43·68	45·05	41·47	41·91
Oxide of iron and alumina	18·70	19·68	19·42	17·84
Insoluble silicious matter	7·77	2·34	10·13	10·10
Total	100·00	100·00	100·00	100·00

Besides Cambridgeshire and Suffolk, the counties of Norfolk, Bedford, and Buckingham produce phosphatic nodules of various degrees of value to the manure manufacturer. The following analysis represents the chemical character of a good sample of Bedfordshire coprolites:—

General Composition of Bedfordshire Coprolites.

Moisture and water of combination	3·35
Phosphoric acid [1]	23·47
Lime	30·29
Oxide of iron	5·39
Alumina, magnesia, and fluorine	7·24
Carbonic acid [2]	3·45
Insoluble silicious matter	26·81
	100·00

[1] Equal to tribasic phosphate of lime . . . . . 51·24
[2] Equal to carbonate of lime . . . . 7·84

Most of the diggings in Bedfordshire furnish brown-coloured coprolites, containing a good deal of oxide of iron, and resembling in their chemical character Suffolk coprolites.

Welsh or Silurian Phosphate.—Phosphatic minerals were discovered some years ago in several places in North Wales. The phosphatic deposits occur not far from the lead-bearing clay-slate districts of Llangynog. The rocks are Silurian, of the Llandeilo series, and the phosphatic minerals occur in clay-slate.

Mr. Hope Jones, of Hooton, Cheshire, has the merit of having first directed attention to an extensive deposit of phosphatic minerals, which he discovered, whilst searching for other minerals, in the neighbourhood of a place called Cwmgynon, about twenty miles west of Oswestry. The strata (clay-slate) in this locality contain several beds of contemporaneous felspathic ash and scoriæ; and the usual fossils of the Llandeilo series are found, but not in great numbers.

The strata of the district are vertical, and the mine at Cwmgynon has a good natural drainage to a depth of about 500 ft. It can be economically worked in galleries for phosphatic limestone and black phosphatic shale. A true vein or fissure, containing mica and metallic deposits, separates the phosphatic limestone from the black phosphatic shale. The vein and accompanying phosphatic deposits run east and west.

The black phosphatic slate or band is fully 18 in. thick, and the limestone-bed from 8 ft. 6 in. to 9 ft. The vein which separates the two deposits from each other is 14 to 16 in. wide, and filled partially with white pipe-clay, calcareous spar, and copper and iron pyrites.

Since the discovery of the phosphate mine at Cwmgynon, others of a similar character have been found in North Wales; and to some extent Silurian phosphate has made its way into the hands of manufacturers of superphosphate of lime. The proportion of phosphoric acid in the black shale of Cwmgynon varies greatly. Towards the summit of the hill it is not nearly so rich in phosphoric acid as at a lower level, where it appears in compact masses, free from carbonate of lime, and containing but little iron pyrites, of which considerable proportions occur in the shale from a higher level.

A specimen taken from the mine, and weighing about 1 cwt., on analysis gave the following results:—

Composition of a Sample of Silurian Phosphate.

Organic matter and loss on heating (chiefly graphite)	3·98
Phosphoric acid [1]	29·67
Lime	37·16
Magnesia	·14
Oxide of iron	1·07
Alumina, fluorine, and loss in analysis	5·84
Insoluble silicious matter	22·14
	100·00

[1] Equal to tribasic phosphate of lime . . . . . 64·77

In this specimen of Silurian phosphatic shale no iron pyrites was visible to the naked eye, and as it contained but little iron, iron pyrites cannot have been present in appreciable quantities. It was also free from carbonate of lime; and besides black carbon, insoluble shale, alumina, and some fluoride of calcium, it contained the largest percentage of phosphate of lime ever found in picked samples from the Cwmgynon mine. In some places the black shale contains only from 25 to 30 per cent. of phosphate of lime. It has been stated that it varies greatly in composition at different depths of the mine. The black shale, moreover, passes gradually into the phosphatic limestone-bed, and in places contains from 10 to 15 per cent. of carbonate of lime and magnesia.

Composition of Two Cargo-samples of Silurian Phosphate.

	No. 1	No. 2
Organic matter and loss on heating	4·89	3·21
Phosphoric acid [1]	18·67	13·14
Lime	26·37	26·52
Oxides of iron and alumina, fluorine, carbonic acid, &c.	26·06	29·65
Insoluble siliceous matter	24·01	27·48
	100·00	100·00
[1] Equal to tribasic phosphate of lime	40·75	28·68

Mineral phosphates containing not more than the percentage of phosphate of lime were found in these cargoes, and so large a proportion of oxide of iron and alumina are hardly saleable in this country.

Immense quantities of phosphatic shale unquestionably exist in North Wales; but the attempts to raise this mineral have not hitherto been successful commercially. In 1875 the quantity of phosphorite returned to the Mining Record Office as being raised at Berwyn, Llangyny, amounted to only 122 tons 11 cwt.

The following analyses of selected specimens of black shale from the mine at Cwmgynon, in North Wales, are illustrations of the variable character of this phosphatic mineral:—

Composition of Four Samples of Black Silurian Shale.

	No. 1	No. 2	No. 3	No. 4
Organic matter and loss on heating (chiefly black carbon or graphite)	6·10	4·37	6·25	3·67
Phosphoric acid [1]	25·26	24·78	23·31	26·88
Lime	33·58	35·09	28·10	35·36
Magnesia	·31	·13	5·22	·96
Oxide of iron	1·01	1·08	·55	1·89
Alumina, fluorine	1·00		1·21	5·58
Carbonic acid, and loss	—	—	12·01	—
Iron . 3·51 / Sulphur . 4·02 (iron pyrites)	7·52	3·65 4·19 7·84	1·80 1·49 3·79	1·69 1·93 3·62
Sulphuric acid	·17	·21	·16	—
Insoluble siliceous matter	28·24	25·11	20·28	22·04
	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	55·02	54·08	51·02	58·68

Canadian Phosphate.—Canadian phosphate is a variety of apatite which occurs in more or less distinct crystalline masses, or in crystals of a light green colour. It is found in large quantities in Canada, and occurs in fissures of granitic rocks, generally associated with gneiss or mica-slate. Usually it reaches this country in hard and heavy pieces, varying in size, and weighing from ½ lb. to 3 lb. and upwards. Occasionally perfect crystals in the shape of six-sided prisms may be picked out from cargoes of Canadian apatite. These crystals have a light green colour, and glass-like lustre and brittle texture. In this pure state the mineral is a definite compound of phosphate of lime and fluoride of calcium. The commercial article, in addition to these constituents, contains a little oxide of iron, which imparts to it generally a light green and sometimes a reddish tint, and more or less of the rock in the fissures of which it is found. The shiny blades of mica, which generally are mixed up with Canadian apatite, give it a glistening appearance. Good cargoes of Canadian phosphate contain on an average from 70 to 72 per cent. of phosphate of lime, and cargoes are rarely shipped from Canada which contain less than 65 per cent. of phosphate of lime.

The following analyses will convey a good idea of the high quality which characterises most samples of Canadian phospha

Composition of Canadian Phosphates.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Moisture, water of combination, and loss on ignition	·62	·10	·11	1·09	·89	1·83
Phosphoric acid [1]	33·51	41·54	37·68	30·84	32·53	31·77
Lime	46·14	54·74	51·04	42·72	44·26	43·62
Oxide of iron, alumina, fluorine, &c.	7·83	3·03	6·88	13·32	12·15	9·28
Insoluble silicious matter	11·90	·59	4·29	12·03	10·17	13·50
	100·00	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	73·15	90·68	82·25	67·32	71·01	69·35

Russian Phosphates.—Russia possesses extensive tracts of land in the Governmental department of Koursk where coprolitic or phosphatic nodules occur in immense quantities. Russian coprolite beds are not as yet utilised to any extent; but there can be no doubt that they are of great importance to Russian agriculture, and doubtless will be explored at no very remote period.

Spanish Phosphorite.—General Composition of Twelve Cargo-samples of Spanish Phosphorite imported into England in 1875.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Water	·58	1·10	4·99	·54	·34	1·14
Phosphoric acid [1]	34·47	33·26	32·30	31·07	30·53	29·45
Lime	45·73	48·20	47·20	42·42	45·70	42·65
Fluorine, and a little oxide of iron and alumina, carbonic acid, &c.	4·08	9·21	10·53	4·21	13·50	9·35
Insoluble silicious matter	15·14	8·23	4·98	21·76	9·78	17·41
	100·00	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	75·25	72·60	70·51	67·83	66·65	64·28

	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
Water	·84	·44	·55	2·24	·47	·99
Phosphoric acid[1]	27·94	27·87	26·61	26·55	25·74	18·71
Lime	40·09	36·50	37·85	38·13	34·06	33·14
Fluorine, oxide of iron, alumina, carbonic acid, &c.	10·03	2·73	10·24	10·18	2·52	18·02
Insoluble silicious matter	20·20	32·46	24·75	22·90	37·21	29·14
	100·00	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	60·99	60·84	58·09	57·96	56·19	40·84

In concluding this section, Dr. VOELCKER adds a complete analysis of a sample of Spanish phosphate which he made some time ago:—

Detailed Composition of a Sample of Spanish Phosphorite.

Water	3·59
Phosphoric acid[1]	33·38
Lime	47·16
Magnesia	traces
Carbonic acid[2]	4·10
Sulphuric acid	·57
Oxide of iron	2·59
Alumina	·89
Fluorine and loss in analysis	4·01
Insoluble silicious matter	3·71
	100·00
[1] Equal to tribasic phosphate of lime	72·87
[2] Equal to carbonate of lime	9·31

The better qualities of Spanish or Portuguese phosphates, when ground fine and treated with sulphuric acid, produce light-coloured, concentrated superphosphates. They find a ready sale in the English market, and fetch a better price per unit per cent. of phosphate of lime than coprolites and mineral phosphates containing much oxide of iron and alumina, inasmuch as superphosphates made from high-grade Spanish phosphate retain their high percentage of soluble phosphate unaltered on keeping; whilst those made from materials containing much oxide of iron and alumina, on keeping become poorer in soluble phosphate, a portion of the soluble phosphate becoming precipitated, or reduced into insoluble phosphate by the presence of oxide of iron and alumina.

German or Nassau Phosphate.—In 1864, Mr. VICTOR MEYER, of Limburg, subsequently proprietor of several extensive phosphate mines in the Duchy of Nassau, made the important discovery of a rich phosphate deposit in the neighbourhood of Staffel, a village near Limburg, in the Lahn Valley.

This discovery created a good deal of sensation at the time, and gave a powerful stimulus to enterprising men to search the length and breadth of the Lahn Valley and adjoining districts for phosphates. These explorations brought to light the existence of phosphate deposits in many other places in the Lahn Valley; and at the present time phosphate mines are worked in the neighbourhood of Wetzlar, Weilburg, Limburg, Dehren, Staffel, Medingen, Weilbach, and numerous other places.

The most extensive Lahn phosphate deposits are found on the left side of the river Lahn below Weilbach. The phosphate occurs in pockets, more particularly in places where limestone, dolomite, greenstone, and a calcareous amygdaloid called locally Schalstein, are intermixed with each other. It is found in these pockets embedded in a ferruginous clay, and is obtained in lumps of various sizes differing greatly in appearance.

In some places the Nassau phosphate forms compact masses, having an earthy

fracture, and light grey or yellow colour. In other localities it appears as a kind of conglomerate of broken pieces of phosphate cemented together by a red or brown-coloured clay, and intermixed with greenstone, manganese, and ironstone. More rarely it occurs in slates with a shaly fracture, and still more rarely in crystalline masses.

After these general remarks on German, Nassau, or Lahn phosphate, as it is called indiscriminately in England, Dr. VOELCKER directs attention more especially to the chemical composition of a number of representative specimens and cargo-samples which have passed through his hands during the last ten years.

Detailed Composition of Three Specimens of rich Nassau Phosphate (Staffelite).

	No. 1	No. 2	No. 3
Water	·65	·25	·98
Phosphoric acid [1]	40·56	38·12	36·19
Lime	56·29	53·02	49·44
Oxide of iron	1·21	·93	·96
Alumina			3·07
Magnesia	·97	·60	2·68
Fluorine (by difference)		3·16	
Carbonic acid [2]	—	2·75	1·87
Sulphuric acid	—	·09	—
Silica	·32	·09	4·81
	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	88·54	83·21	79·01
[2] Equal to carbonate of lime	—	6·25	4·25

General Composition of Various Samples of Nassau, or Lahn Phosphates.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
Moisture and water of combination	2·32	2·40	2·42	2·54	1·39	3·86
Phosphoric acid [1]	33·49	32·05	31·08	30·52	26·67	26·02
Lime	45·62	44·44	42·53	42·20	38·27	37·62
Oxide of iron	3·07	13·94			3·41	5·06
Alumina, fluorine, carbonic acid, &c.	9·49		15·77	16·16	8·65	10·32
Insoluble silicious matter	5·21	7·17	8·20	8·58	21·61	17·12
	100·00	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	73·11	69·96	67·85	66·63	58·22	56·80

It may be stated that impure varieties are much more abundant in the Lahn Valley than those richer in phosphoric acid. Although the quality may be considerably raised by the plan adopted in the German phosphate mines, of sifting and washing the impurer sorts, a large proportion of the mine produce is too poor in phosphate of lime to repay the cost of exportation to England, for unless a cargo contains about 65 per cent. of phosphate of lime, German phosphate cannot be profitably sent into this country.

French Coprolites.—The most valuable deposits in France occur in the Ardennes, but these are, as yet, but partially developed. Those found near Boulogne are largely imported into England. The following is Dr. VOELCKER's analyses of five varieties of the Boulogne coprolites:—

	No. 1	No. 2	No. 3	No. 4	No. 5
Moisture	·84	·79	1·08	1·18	1·74
Water of combination and loss on heating	3·14	3·24	3·08	1·91	1·94
Phosphoric acid [1]	21·06	21·27	21·27	20·70	17·69
Lime	33·05	35·38	33·58	30·41	31·12
Carbonic acid [2]	3·55	5·25	4·52	3·94	5·13
Sulphuric acid	6·81	·89	·90	3·24	·65
Fluorine, and loss in analysis		2·08	2·77		4·96
Magnesia	·58	·25	·69	·83	·56
Oxide of iron	2·89	3·63	3·54	6·24	3·52
Alumina	3·09	3·06	3·64	5·39	4·04
Insoluble silicious matter	24·98	23·56	24·93	26·16	28·45
	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	45·97	46·43	46·43	45·19	38·61
[2] Equal to carbonate of lime	8·07	11·93	10·27	8·95	11·66

It will be seen that Boulogne coprolites contain about one-fourth their weight of insoluble silicious matter, and considerable proportions of oxide of iron and alumina. Like most coprolites, they also contain a good deal of fluorine. On the whole, they are poorer in phosphate of lime, and richer in oxide of iron and alumina, than Cambridge coprolites. They resemble closely in composition the inferior phosphatic nodules which at the present time are dug up in Bedfordshire and in Norfolk.

A superior variety of French coprolites is found in the Valley of the Rhone, near Bellegarde, close to the Swiss frontier.

The following analyses represent the chemical character of two samples of such coprolites:—

	No. 1	No. 2
Moisture and water of combination	2·79	2·95
Phosphoric acid [1]	25·10	27·76
Lime	40·11	41·88
Oxide of iron and alumina / Fluorine	14·38	10·56
Carbonic acid, &c.[2]	—	7·10
Insoluble silicious matter	17·62	9·75
	100·00	100·00
[1] Equal to tribasic phosphate of lime	54·79	60·60
[2] Equal to carbonate of lime	—	16·14

No. 1 sample was taken from a bed at Bellegarde, in the South of France, consisting almost entirely of phosphatic fossils, as terebratula, belemnites, ammonites, and sea-urchins.

The discovery of mineral phosphates in the valley of the Lahn, in Nassau, has lately been eclipsed by that of extensive and valuable phosphatic deposits in the valley of the Lot, a tributary of the river Garonne, which flows through the upper and middle beds of the Jura and the lias formations. During the last few years large quantities of phosphate have been imported into England from the South of France. This phosphate is known in England under the name of French, or Bordeaux phosphate, it being usually shipped from that port. Like Lahn phosphate, the French deposit occurs in pockets, and varies greatly in appearance, texture, and in its chemical composition and commercial value.

Occasionally French phosphate is found in snow-white compact masses of a moderate degree of hardness, and breaking with an earthy fracture. More frequently it

has an opal-like appearance, a greyish colour, a waxy lustre, and conchoidal fracture. The white and opal-like specimens, I find, are very rich in phosphoric acid, as are also those which occur in botryoidal masses, or stalactitic forms.

The more ordinary kinds have a yellow or brown colour; they are dense and hard to grind, but readily decomposed by sulphuric acid, and well adapted for the manufacture of high-grade superphosphates.

Inferior samples usually have a dark-brown colour, or they appear as mottled and irregular masses or breccias, closely resembling some descriptions of Lahn phosphate, from which they are hardly distinguishable in appearance, or by their chemical composition.

When French phosphate was first brought into the English market, it frequently contained over 74 per cent. of phosphate of lime, and rarely less than 71 per cent. It would appear that at first only the richer deposits were worked in France, and sent over to England, probably with a view of securing a good reception to the newly-discovered deposits.

A full analysis of Bordeaux phosphate is given.

The sample No. 1, it will be seen, contained 77½ per cent. of phosphate of lime, a little oxide of iron and alumina, and about 4 per cent. more carbonate of lime than the second sample, which also contained but little oxide of iron, but a good deal of alumina.

Detailed Composition of Two Samples of rich Bordeaux Phosphate.

	No. 1	No. 2
Moisture	2·28	3·28
Water of combination	2·52	1·24
Phosphoric acid[1]	35·51	33·72
Lime	47·81	44·23
Magnesia	·12	1·74
Fluorine (by difference)	·89	
Carbonic acid[2]	5·06	3·26
Sulphuric acid	·64	—
Oxide of iron	2·60	2·06
Alumina		6·42
Insoluble siliceous matter	2·37	3·45
	100·00	100·00
[1] Equal to tribasic phosphate of lime	77·52	73·61
[2] Equal to carbonate of lime	11·50	7·40

General Composition of high quality French Phosphates.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Moisture	2·60	2·90	3·01	3·07	3·43	3·50	4·23
Water of combination	2·62	1·01	2·11	·50			
Phosphoric acid[1]	34·46	34·91	34·01	35·30	34·01	34·71	33·34
Lime	46·11	48·16	46·77	46·11	47·79	46·73	48·11
Oxide of iron and alumina, carbonic acid, &c.	10·77	9·44	11·61	12·40	12·07	11·01	10·64
Insoluble siliceous matter	3·44	3·58	2·49	2·59	1·80	4·05	3·68
	100·00	100·00	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	75·23	76·21	74·24	77·06	76·21	75·77	72·76

South Carolina, or Charleston, Phosphates.—Professor TUOMEY, in his *Geology of South Carolina*, p. 153, says:—

'The calcareous strata of the Charleston Basin occupy an irregular area of 55 to 60 miles, extending from the Santee on the east to the Ashepoo River on the west,

and lying between the Atlantic Ocean on the south and east, and the limits of the Buhrstone formation on the north.

'Of these the Santee beds are geologically the lowest and oldest, and consist of thick beds of white limestone, marl, and green-sand. They dip or slope gently towards the south, and underlie the newer Eocene marls of the Cooper and Ashley rivers, of which those of the Ashley are most recent, and constitute the top of the Eocene series.

'The combined thickness of these with those of the Santee beds is reckoned at 600 or 700 feet. The beds underlie the city of Charleston, as proved by borings taken in 1824 from the Artesian well, and extend under the harbour, as shown by specimens of marl brought up by the anchors of vessels, and also by borings from the well at Fort Sumter, which, at 300 feet, brought up the green-sand of the Santee beds.'

On page 235 he states:—

'The other marls and marlstones of the State present every variety, from a pulverulent mass to the solid rock. . . . They are rich in calcareous matter beyond example, and in addition to this they contain phosphate of lime in very valuable proportion. This exceedingly interesting ingredient is found most abundantly on the marls of the fish bed of the Ashley, where it is derived from the bones of marine and land animals buried in that deposit. The remains of crustaceous animals found in nearly all the beds indicate another source of this substance.'

In or about the year 1844, Professor HOLMES published the results of his experiments on 'Marling,' in the columns of the *South Carolina Agriculturist*, and in describing the superposition of the beds in his marl-pit, mentions a remarkable bed of nodules as 'conglomerates,' 12 in. thick, bedded in the clay and sand, which overlaid the heavy beds of marl below. Whilst searching for phosphatic materials, Dr. PRATT found in 1867 that a bed or stratum, outcropping within ten miles of the city of Charleston, contained phosphatic nodules in great abundance.

This bed or stratum, Dr. PRATT says, has been long known in the history of the geology of South Carolina as the Fish Bed of the Charleston Basin. It is found outcropping on the banks of the Ashley, Cooper, Stono, Edisto, Coosaw, and Combahee Rivers, or their tributaries; but it is developed most heavily and richly on the Ashley, and no doubt extends along the coast east, and especially west, to unknown limits, and has been found as far inland as forty or fifty miles.

According to the same authority, the bed varies from 17 to 18 in. in thickness, sometimes, though rarely, increasing to two or three feet, and in some places it thins out to a few scattering nodules on or near the surface. It consists essentially of indurated, irregular-rounded nodules, buried in an adhesive and tenacious blue clay and sand; sometimes, however, it exists in continuous beds, or large lumps, or conglomerates of soft chalky consistency, as if it had been originally a soft pasty mass of phosphatic mud, that has since become semi-consolidated. Associated with these are a most wonderful assortment of animal remains, among which bones of marine animals are so abundant as to have induced Professor L. AGASSIZ, twenty years ago, to call it 'the Fish Bed of the Charleston Basin.'

Detailed Composition of Two Examples of South Carolina Land Phosphates.

	No. 1	No. 2
Moisture	2·78	5·38
Water of combination		1·70
Phosphoric acid[1]	24·15	24·66
Lime	35·78	37·18
Magnesia	·67	·76
Oxide of iron	3·99	4·15
Alumina	3·20	4·90
Carbonic acid[2]	2·91	4·08
Sulphuric acid	1·84	not determined
Alkaline chlorides (common salt)	2·15	—
Fluorine and loss	3·40	2·05
Insoluble silicious matter (fine sand)	19·13	15·05
	100·00	100·00
[1] Equal to tribasic phosphate of lime	52·72	53·83
[2] Equal to carbonate of lime	6·61	9·27

Composition of South Carolina Land Phosphates.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Moisture . . . . } Water of combination . . }	7·40	2·29	10·30	3·93	8·01	{ 6·50 { 1·09	7·62 1·34
Phosphoric acid[1] . . .	26·50	24·20	22·06	25·47	23·93	24·80	23·35
Lime	37·20	38·71	37·24	40·11	36·75	38·54	36·41
Oxide of iron and alumina, magnesia, carbonic acid, &c. }	16·27	17·28	15·45	16·82	16·88	17·01	16·54
Insoluble silicious matter .	12·63	17·43	14·95	11·62	14·43	11·87	14·67
	100·00	100·00	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime . }	57·55	53·02	48·16	55·60	52·24	54·14	50·98

Composition of Carolina River Phosphates.

	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
Moisture . . . . } Water of combination and loss on ignition . . }	4·07	1·56	2·57	2·04	1·80	2·60	2·68
Phosphoric acid[1] . . .	25·44	26·50	27·11	26·07	26·89	27·44	25·31
Lime	45·07	42·28	42·79	42·54	42·43	42·45	39·27
Magnesia, carbonic acid, oxide of iron, alumina, &c. }	15·16	18·47	17·54	17·57	17·30	17·80	16·19
Insoluble silicious matter .	7·26	10·80	9·99	10·29	11·43	9·42	16·55
	100·00	100·00	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime . }	62·09	58·70	59·18	58·87	58·70	59·00	55·25

Sombrero Phosphate.—Sombrero Rock phosphate is found on the small uninhabited island, one of the group of the Leeward Islands, in the Caribbean Sea, about 60 miles east of the Danish West Indian Islands, and the same distance from Guadeloupe.

The following is the composition of four cargoes, imported into England in the course of the year 1875:—

Composition of Sombrero Phosphate.

	No. 1	No. 2	No. 3	No. 4
Moisture	—	7·03	7·63	} 8·02
Water of combination	8·14	1·64	1·49	}
Phosphoric acid[1]	32·82	32·45	31·70	31·73
Lime	45·33	46·11	46·02	46·60
Carbonic acid[2]	6·58	7·35	7·30	5·99
Oxide of iron, and alumina, &c. . .	7·14	4·20	4·87	7·07
Insoluble silicious matter . . .	·99	1·16	1·09	·60
	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime .	71·65	70·84	69·20	69·27
[2] Equal to carbonate of lime . .	12·68	16·64	16·59	13·61

Navassa phosphate is derived from another small uninhabited island in the Caribbean Sea. The bulk of the deposit consists of globular grains of phosphate of lime, cemented together into hard masses, and mixed with oxide of iron, alumina, carbonate of lime, and silicious matter.

Detailed Composition of Navassa Phosphate.

	No. 1.	No. 2	No. 3
Moisture	5·91	8·50	12·08
Water of combination and organic matter	5·46	4·15	
Phosphoric acid[1]	31·18	28·47	31·15
Lime	37·70	34·07	38·58
Magnesia	—	·45	—
Carbonic acid[2]	2·38	2·30	2·29
Oxide of iron	4·18	4·49	3·06
Alumina	9·11	9·48	9·30
Sulphuric acid, fluorine, &c.	1·16	1·91	
Insoluble silicious matter	2·92	6·28	2·62
	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	68·07	62·15	68·01
[2] Equal to carbonate of lime	5·41	5·22	5·20

St. Martin's Phosphates.—These are found on St. Martin, a small island belonging to the Windward Islands.

The following are analyses of two samples of St. Martin's phosphate:—

	No. 1	No. 2
Moisture and water of combination	5·04	3·56
Phosphoric acid[1]	24·14	36·13
Lime	47·69	50·41
Magnesia	·38	·22
Sulphuric acid	·18	·45
Carbonic acid[2]	14·20	6·59
Oxide of iron	1·51	1·40
Alumina	2·99	1·37
Insoluble silicious matter	3·87	·87
	100·00	100·00
[1] Equal to tribasic phosphate of lime	52·70	78·89
[2] Equal to carbonate of lime	32·27	14·98

Aruba Island Phosphates.—Another phosphatic rock or mineral has recently been discovered on Aruba Island, one of the Leeward Islands, in the Caribbean Sea, situated 12° 36' north latitude, and 70° 8' west longitude.

The samples of Aruba rock phosphate which have come under notice are compact hard, stone-like masses of a light-brown or yellowish colour, with darker, chocolate-brown, coloured bands and blotches, which give the Aruba phosphate a peculiar and characteristic appearance. Aruba phosphate contains from 63 to 78 per cent. of phosphate of lime, with variable quantities of carbonate of lime, oxide of iron, alumina, insoluble silicious matter, and similar impurities usually found in phosphatic minerals. In illustration of the chemical character of Aruba phosphate, analyses of five samples of Aruba phosphate are given.

	No. 1	No. 2	No. 3	No. 4	No. 5
Moisture and water of combination	5·55	3·79	5·54	3·79	5·48
Phosphoric acid [1]	31·11	33·04	28·95	33·04	34·94
Lime	41·69	47·53	30·18	47·53	42·91
Carbonic acid [2]	6·69		·98		
Oxide of iron	14·72	14·00	9·26	14·60	16·43
Alumina, &c.			17·22		
Insoluble silicious matter	·24	1·04	7·87	1·04	·24
	100·00	100·00	100·00	100·00	100·00
[1] Equal to tribasic phosphate of lime	67·91	72·13	63·20	72·13	76·28
[2] Equal to carbonate of lime	15·20	—	2·23	—	—

Redonda Phosphate.—Some years ago a peculiar phosphate, mistaken at the time for phosphate of lime, was discovered on the Redonda Island.

This mineral consists principally of hydrated phosphate of alumina, contaminated with more or less oxide of iron and insoluble silicious matter. Most samples contain no lime whatever, and in consequence Redonda phosphate cannot be used in the manufacture of ordinary superphosphate of lime.

It is, however, utilised in chemical works for the production of alum, for which several patents have been taken out in England, and it yields impure phosphoric acid as a by-product in the manufacture of that alum.

Composition of Four Samples of Redonda Phosphate.

	No. 1	No. 2	No. 3	No. 4
Moisture and water of combination	23·23	21·15	27·70	24·20
Phosphoric acid [1]	36·96	37·04	19·40	38·69
Alumina and oxide of iron	36·38	32·26	25·65	35·53
Insoluble silicious matter	3·4	9·55	27·25	1·95
	100·00	100·00	100·00	100·00
[1] Corresponding to tribasic phosphate of lime	80·66	80·86	42·35	84·09

Alta Vela Phosphate.—Alta Vela Rock phosphate is found on the small island of Alta Vela, near St. Domingo, and is another form of crude phosphate of alumina, which may be used for the same purposes for which Redonda phosphate is employed. It appears to vary in composition to a greater extent than Redonda phosphate.

The following is the composition of three samples of Alta Vela (St. Domingo) phosphate:—

	No. 1	No. 2	No. 3
Moisture	15·31	19·33	4·19
Water of combination			13·19
Phosphoric acid [1]	20·07	26·23	10·66
Oxide of iron	7·35	7·23	2·79
Alumina	21·20	20·22	21·95
Insoluble silicious matter	32·84	26·99	27·19
	100·00	100·00	100·00
[1] Corresponding to tribasic phosphate of lime	43·81	57·26	67·37

Alta Vela phosphate is a harder rock than Redonda phosphate, and of a lighter colour.

Dr. Voelcker concludes his most valuable paper with the following remarks:—

All the minerals described in the preceding pages are of little use for agricultural purposes, except when they are treated with sulphuric acid. Some, for instance, German phosphates, have been usefully applied to the land simply in a finely powdered state, and no doubt in the immediate neighbourhood where phosphatic minerals of a low quality are found, and are procurable at a trifling expense, they may be used with advantage in a powdered state, like marl, in large quantities, say at the rate of a ton or more per acre; but as a rule, phosphatic minerals are mainly of use to the manufacturer of superphosphate, whose aim it should be to render, by treatment with sulphuric acid, the insoluble phosphate of lime contained in them as completely soluble in water as possible.

Soluble phosphate of lime is a definite chemical compound, and in all respects just as valuable for manuring purposes as soluble phosphate obtained from bones. On the other hand, insoluble phosphate, in the shape of undecomposed phosphatic minerals, has little or no practical manuring value, whilst in the shape of bone-dust it is sufficiently available as plant-food to be of considerable value.—The papers of Dr. Augustus Voelcker, F.R.S., in the *Journal of the Royal Agricultural Society of England*, published in 1861 and 1875; *The Potton and Wicken Phosphate Deposits*, by J. J. Harris Teall, B.A.

PHOSPHATIC WOOD. Dr. Voelcker gives the following as the composition of fossil phosphatic wood found in Bedfordshire coprolite beds:—

Moisture	1·12
Organic matter and water of combination	3·49
Lime	47·75
Phosphoric acid[1]	32·96
Oxide of iron and alumina, carbonic acid, &c.	10·49
Insoluble silicious matter	4·19
	100·00

[1] Equal to tribasic phosphate of lime . . . . 71·95

The structure of the wood was most distinctly preserved. It will be seen that the fossilised wood had lost almost all its organic matter, and that it had been replaced mainly by phosphate of lime. The specimen analysed by me contained as much as 72 per cent. of phosphate of lime, and, comparatively speaking, little silicious matter and oxide of iron and alumina.

PHOSPHATE OF YTTRIA. A very fine yellow crystalline example has been found by Mr. A. Howitt at Bonnry, Gippsland, associated with very highly modified minute crystals resembling zircon.—*Report of Progress, Geological Survey of Victoria.*

PHOSPHIDE OF COPPER. M. Delatot and others now regard the supposed alloy of copper and phosphorus as a true chemical compound. According to Delatot, the percentage of phosphorus varies from 2 to 4, between which there may be an infinity of degrees, although for industrial purposes five varieties meet all the requirements. These are formed with 2 per cent. of phosphorus, 2½ per cent., 3, 3½ and 4 per cent. Above 4 phosphor bronze is useless, but between 3 and 4 per cent. the metal is claimed to be superior to any other alloy. See Bronze, Phosphorus.

PHOSPHOR BRONZE. (Vol. iii. p. 554). Dr. Percy (*Metallurgy*, vol. i. 1st ed. p. 270) first notices the combination of phosphorus and copper. Subsequently the combination of phosphorus and bronze has been largely employed. The strength of this alloy has been already referred to in the former volumes. The many peculiarities of this alloy are noticed in the *Scientific American* in one of the excellent articles on the Centennial Exhibition at Philadelphia, which have appeared in that journal, and the following extract gives some evidences of it:—

'This alloy has been in use but three or four years, but such are its remarkable properties in adaptation to many of the most important engineering necessities, that it has taken great strides towards supplanting old and favourite metals and compounds. It possesses extraordinary tenacity, while it is more easily manipulated than the metals and alloys whose places it is rapidly taking. One of the most important characteristics is, that it resists abrasion and wear from frictional rubbing of surfaces far more persistently than is true of any other known metal or alloy. It exceeds in this particular even hardened steel for some purposes. The specimens exhibited consisted of a considerable variety of bearings and working parts of machinery, wrenches, scissors, hammers, &c., the most of which have been subjected

to tests appropriate to them, and the result shown. Among these are a pair of worms, or endless screws, which have been run in articulation with toothed worm-wheels for eighteen months in a place, and under circumstances such as had, previous to the adoption of this material, destroyed them when made of brass in twelve days, and these specimens showed but slight signs of wear after such an ordeal. A large shaft-bearing forming a step, which had suffered more than ordinary pressure on its collar, and which had been repeatedly replaced when made of brass, after three weeks' service, had suffered a diminution in the thickness of collar scarcely appreciable after eight months' use, the mills running night and day. An eccentric strap which had run eighteen months, was reduced in thickness at the crown ¼ in., where the ordinary gun-metal straps had been replaced every three months. Perhaps the most striking example given of the ability of this alloy to resist wear and tear is that of an hydraulic pump plunger. This plunger had been at work for 372 days at the rate of 60 strokes per minute, under a pressure of three tons to the sq. in., and showed no signs of wear; while lying by its side is a hardened steel plunger which had been subjected to the same work during sixty days, and was worn down to such an extent as to be of no further use. Phosphor bronze is one of the metallic compounds which does not contract in cooling until after the point of solidification has been completely reached, which property, in common with zinc and many of its alloys, renders the casting from it in perfection of fine-membered objects, such as busts, statuary, and other ornamental work. This property is well shown in two figures or busts, the one finished, and the other just as taken from the mould; the latter being as sharp in all its features and lines as the former. Specimens of wire made from this alloy are also shown, with tabulated data of experimental tests made with it, which established that, while it is more ductile than copper, it exceeds in tenacity some of the strongest of steels. This entire series of examples will well repay a visit from even the most unprofessional man who may be in search of only general information, and contains an invaluable store for the mechanician and engineer.' See Bronze, Phosphor.

PHOSPHORITE, Estremadura. This is a mineral substance containing phosphoric acid found in the province of Estremadura, and now sent largely to Hamburg to be used for manure. It is of a yellow-reddish colour, knotty, and as hard as stone. This mineral does not contain nearly so much iron oxide as the Lahn phosphorite, and is therefore not liable to the risk of the phosphoric acid becoming insoluble, which is often the case.

The percentage of phosphoric acid in this mineral is only about 28 per cent., about 6 per cent. less than the best kinds of guano, and it furnishes a superphosphate of 14 to 16 per cent. dissolved acid. The superphosphate has a dry crumbling form. The quantity of carbonate of lime varies greatly. The following are the results of the various analyses:—

Porto Packet.

Phosphate of lime	54·691	Phosphoric acid	25·052
Phosphate of magnesia	7·010	"	3·798
Carbonate of lime	8·065		
Sulphate of lime	1·200		
Iron oxide	0·621		
Aluminium oxide	0·165		
Fluoride of calcium	1·620		
Manganese	trace		
Silicic acid	25·720		
Water	0·250		
	99·242	Phosphoric acid	28·850

Maria Sophia.

Phosphate of lime	62·353	Phosphoric acid	28·653
Phosphate of magnesia	1·605	"	1·026
Carbonate of lime	13·688		
Sulphate of lime	2·440		
Iron oxide	0·626		
Aluminium oxide	0·086		
Fluoride of calcium	1·204		
Silicic acid	16·412		
Water	1·175		
	99·589	Phosphoric acid	29·679

Catherine.

Phosphate of lime	67·360	Phosphoric acid	26·280
Phosphate of magnesia	0·708	"	0·383
Carbonate of lime	7·385		
Sulphate of lime	1·590		
Iron oxide	0·453		
Aluminium oxide	0·405		
Fluoride of calcium	1·622		
Silicic acid	20·428		
Water	0·790		
	99·950	Phosphoric acid	26·663

Stamboul.

Phosphate of lime	59·594	Phosphoric acid	27·300
Phosphate of magnesia	3·077	"	2·155
Carbonate of lime	13·327		
Sulphate of lime	0·858		
Iron oxide	0·910		
Aluminium oxide	0·427		
Fluoride of calcium	0·983		
Manganese	trace		
Silicic acid	19·164		
Water	0·721		
	99·961	Phosphoric acid	29·465

A new form of phosphorite has been found in some specimens of phosphorite recently discovered in Southern Russia. The mineral occurred in rounded masses, varying in size from 5 to 9 in. in diameter. The outer surface was smooth, and presented an appearance highly suggestive of the form being due to the action of running water, but upon fracturing several of these balls he found in every instance that they were composed of a number of fibres radiating from the centre, of small size, and of bluish-grey colour, having a hardness of about four. These balls were not solid throughout, but near the centre contain fissures similar to those found in Septaria and clay ironstone, and these fissures were in every case coated with a thin film of phosphorite of a yellowish-brown colour, which he thought might possibly be a small quantity of staffelite. The sp. gr. of the phosphorite was about 3·25. An analysis by Mr. Oxton showed phosphoric acid, 35·18, carbonic acid 1·50; lime, 47·68; oxides of iron and alumina, 2·68; silica, 8·25; water in combination, 1·80; ditto at 2, 127·30; undetermined, 2·97. Equal to tribasic phosphate of lime, 76·88; and carbonate of lime, 3·41. Other analyses have shown a still greater percentage of phosphoric acid, some as much as 82 to 84 per cent. of tribasic phosphate, so that in spite of its unpromising appearance it was really rich in the element so valuable for agricultural purposes. It was possible that further examination of these rocks might show that these phosphate deposits occupied the same geological horizon as those recently discovered in Wales.—Mr. H. H. Gunn, *Transactions of the Mineralogical Society.*

PHOTOGALVANOGRAPHY. (Vol. iii. pp. 562, 573.) The following process is given by Josef Leipold in Dingler's *Journal*. A plate of white glass, as even as possible, is coated with a mixture of 15 grams of gum dissolved in 3 ozs. of water, 4 grams of bichromate of potash dissolved in 1½ grams of water, 1 gram of nitrate of silver dissolved in 1½ oz. of water, and ½ gram of iodide of potassium dissolved in 1 oz. of water. A little glacial acetic acid is added to the mixture. The sensitive plate should be dried at 36° C. for some hours and then exposed to the air of a dark room. The plate is exposed for printing for from three to five hours in diffused light. It is developed with a mixture of 15 parts of water with 1 part of alcohol. A cast is taken with a mixture of 425 parts of spermaceti, 200 parts of stearic acid, 170 of white wax, 70 of asphalt, and 70 parts of graphite. The cast is brushed with a soft hair-pencil to remove irregularities, and then dusted over with finely powdered graphite, and an electrotype is taken in the usual way.

PHOTOGRAPHY. (Photographic Engraving, vol. iii. p. 562. Photographic Printing, vol. iii. p. 564. Photography, vol. iii. p. 566.) Alkaline solutions have been introduced for the development of the photographic image. It has been usually assumed that their sole function is to reduce to the metallic state the particles of bromide of silver which have been acted on by light.

The alkaline developer consists of pyrogallic acid or other oxygen absorber—an alkali such as liquid ammonia, and a 'restrainer' such as bromide of potassium. These are generally mixed together and applied to the film, on which has been impressed an invisible image. Those parts acted on darken under the influence of the solution, whilst, if the surface be in a proper condition, and the proportion of the restrainer to the alkali be well balanced, the portions unacted on by light remain unchanged. The image thus formed is soluble in nitric acid, and further tests show it to be metallic silver.

A series of remarks, founded on very excellent experiments by Captain Abney, R.E., F.R.S., will be found in the *Philosophical Magazine* for December 1876, which should be consulted.

Captain Abney's alkaline developer consists as follows:—

1. Pyrogallic acid	16 grains
Water	1 oz.
2. Bromide of potassium	20 grains
Water	1 oz.
3. Liquor ammonia (·880)	½ oz.
Water	8 ozs.
Or Potash	15 grains
Water	1 oz.

The following improvements in carbon printings by Th. Hoxman are of considerable value:—

1. After the tissue has been sensitised upon the bichromate bath, it must not be pressed too firmly against the glass plate upon which it is laid; otherwise defective parts are produced. As, however, this pressing out of moisture is beneficial, both because the tissue dries faster and assumes a finer surface, I prefer pressing it by means of a polished zinc plate, but equally over the surface.

2. The tissue dries best if the upper margin is clasped between two thin laths by means of clips, and if the laths have been waxed the tissue will not adhere to them when dry.

3. The actinometer may be advantageously covered with a very pale yellow glass, so that the silver paper underneath is longer in printing, for tints are much more distinguishable in a light than a dark impression. My actinometer has inside a movable roller which may be pushed on one side; upon this the paper is easily fixed, permitting a hundred exposures to be given.

4. Carbon tissue prints comparatively quicker in dull weather than in bright light or sunshine; that is to say, a print is of a darker tone if produced by slow printing, than one which has been brought to the same pitch, judging by the actinometer, quickly, in a bright light.

5. To the collodion serving as development basis may be added with advantage a small quantity of negative varnish, as much as it will stand without becoming milky in the water bath. In this way a more stable and firmer film is produced, and one, moreover, which easily quits the glass at the end of the operation.

6. For transparent positives it is best not to employ any substratum at all; the glass may be polished and coated with albumen, as in the negative process, however, without any fear of the image leaving the glass.

7. The best materials to develop upon for ordinary work are fine matt glass and polished zinc. The trimming, mounting, pressing, and retouching of the pictures are the same as in the case of silver prints, only the operations must be performed with a little more care. As regards vigour, tone, glaze, and appearance, carbon prints may be secured quite similar to albumenised pictures. Silver and carbon prints are, indeed, often very difficult to distinguish.

8. In large pictures developed slowly at a low temperature, a material influence may be exercised upon the tints of the background, drapery, and high lights, by the judicious application of a stream of lukewarm water applied by hand.

9. Chrome-alum solution I employ always in a concentrated form. I pour it but once over the image, allow the liquid to remain upon the plate, held in a horizontal position for a short time, and then rinse with water.

10. In developing direct upon paper the waterproof solution of borax, shellac, and soda should be made up with shellac of a reddish-brown tone; it imparts to the paper a pleasant rosy tint similar to that seen in rose-coloured albumenised paper.

11. More than two rows of small pictures should not be developed upon one basis, as prints at the margin of the plate, whose vigour requires to be corrected by the aid

of a warm water stream, can be easily treated; whereas, if there is a middle row of images, these are only dealt with with difficulty.

12. Pictures are more difficult to remove from glass, especially patent plate, when dried rapidly.

13. In the case of pictures having a high gloss, when these are half dry, a two or three-sheet moist cardboard is attached by means of good fresh paste, and upon this is put a sheet of moistened paper, the whole being covered for some time by another glass plate kept down by a moderate weight.—*Photographische Archiv.*

A new carbon process has been introduced by M. Fargier:—

A sheet of paper is allowed to float upon a solution of 5 grams of chloride of iron and a similar amount of citric acid, which are dissolved in 100 grams of water. This paper is afterwards dried in the dark and placed under a negative to print, until a weak image is produced. This print is taken and floated upon a bath of coloured gelatine solution, when it is found that the gelatine attaches itself to the portions of the surface that have been acted upon by light. There remains nothing but to wash the sheet in water, and the picture is finished. If, instead of a coloured solution of gelatine in water, softened tissue were employed, the printed chloride of iron paper being pressed into contact with the same, warm water being used subsequently to separate the two surfaces again, there would perhaps be a step further gained in the simplification of the carbon process, for the pictures would be visible at once during the printing operation, and could therefore be controlled. Dr. Liesegang, writing in the *Archiv*, is of opinion that an improvement in the carbon process may be effected in this direction, and that the Fargier method indicates a branch of the subject which might be investigated with advantage.—*Photographic News.*

Photographs in Colour.—M. de S. Florent gives the following description of his experiments in producing sun-pictures in colour:—

After many unsuccessful attempts, I have at last been fortunate enough to discover a method of producing, with great ease and certainty, heliochromic prints whose colours are closely allied with those of nature. I have obtained by my method reproductions of coloured glass and stamps. I can also obtain landscapes in the camera, but with colours rather weak in nature, the result, no doubt, being capable of improvement by having recourse to a better adapted apparatus. My method of operating, at which I have arrived after numerous trials and experiments, I will now describe:—A sheet of paper, with as fine a grain as possible, is plunged into a silver bath made up as follows: nitrate of silver and distilled water, 20 parts of each; as soon as a solution has been made there is added, alcohol, 100 parts; nitric acid, 10 parts. When the sheet has been thus treated and dried again, it is further plunged into a solution of—

Hydrochloric acid	50 parts
Alcohol	50 "
Nitrate of uranium	1 "

A little zinc white is dissolved into the hydrochloric acid beforehand.

After this double treatment the sheet of paper is exposed to sunlight for a short time, until its surface has assumed a violet blue tint. It is then immersed again, after desiccation, in the silver, as also in the hydrochloric bath. These operations are repeated until a most intense blue has been obtained, this being the only way to secure very vigorous images.

Before the paper is altogether dry it is put into another bath, made up by adding a few drops of a solution of mercury, dissolved in nitric acid, to some distilled water. The sheet is allowed to remain from five to ten minutes in this last-named bath, and is then dried by contact with blotting paper.

The sheet thus sensitised is then exposed to light under coloured glass—a coloured magic-lantern slide, for instance; and after a period of twenty to thirty seconds in the sunlight, an impression on a white ground is obtained, with all the colours of the model. The colours are more vivid, and the rapidity quite as great, if there is added to the bath just mentioned—

Saturated solution of bichromate of potash or ammonia	2 parts
Sulphuric acid	2 "
Chlorate of potash	1 "

To fix the prints, in some degree, they are washed in plenty of water, and then immersed in—

Ammonia	5 parts
Alcohol	100 "

After again washing, the impression is put in a bath saturated with an alkaline chloride. Then, after a final washing, the image will be found to resist for a considerable time the action of diffused light.

1. Much greater rapidity is obtained if the chloride of silver paper is darkened under violet or blue glass.

2. If, on its exit from the nitrate of mercury bath, the sheet is exposed under a coloured glass, and there are interspersed, between the sunlight and the glass, screens or glasses of different colours, it will be observed that the colours appear more rapidly under the yellow, green, and red screens, than under the blue and indigo ones.

It must not be forgotten that Sir JOHN HERSCHEL produced several of the colours of the prismatic spectrum upon papers covered with chloride of silver, which has been allowed to assume a leaden tint by keeping in the dark.

Photographs without the Salts of Silver.—The *Photographic News* publishes some descriptions of the preparation of photographs without the salts of silver, by Dr. DIAMOND. In Mr. ROBERT HUNT's *Researches on Light* will be found several processes by means of which pictures are obtained without any silver salts. Especially the 'chromotype' is a remarkable example of the production of very strongly coloured pictures by the use of the salts of chromic acid.

Working in the same direction with new combinations, Dr. DIAMOND has succeeded in producing some fine results. In tone Dr. DIAMOND's pictures resemble the rich, brown-red engravings of BARTOLOZZI, and possess for many subjects a singularly pleasing and artistic effect. But they have other peculiarities. The image, whilst it is thoroughly embedded, as it were, in the texture of the paper, has nothing of the flat sunken-in effect which such a condition generally produces. It is crisp, bold, and vivid on both sides of the paper, and very beautiful when examined as a transparency by transmitted light. The paper on which they are produced acquires in the treatment something of the quality of vellum; it becomes tough, close, and firm in texture, and a surface somewhat resembling satin. When printed with a masked margin, the prints may be preserved very satisfactorily without mounting. The mode in which the prints in question are produced is as follows:—

Solution No. 1.—Nitrate of uranium	. . . .	360 grains
Nitrate of copper	. . . .	100 „

Dissolve in 5 ozs. of distilled water, and pour into a flat glass dish. Pass any ordinary paper through it which has been sized with gelatine; ordinary writing-paper answers remarkably well, but thin WHATMAN or TURNER's paper is the most reliable; an immersion of a couple of minutes is sufficient to enable the paper to be thoroughly permeated by the solution; it is then suspended and dried in the dark, and will keep any length of time, just as the old iodised paper does in the calotype process. The paper will acquire a compactness very similar to what is called the vegetable parchment. In use it is as sensitive as the usual silver paper—ten minutes may be a medium time for exposure under an ordinary glass negative. When removed from the printing-frame a faint resemblance of the future picture is observed. It should then be passed through the following solution, drawing it to and fro to insure equality of immersion, and the image immediately starts out, of a rich brownish red, and a bronze-like lustre; and when the exact exposure has taken place, there is little difference in viewing the image on either side, the deposit being in the very substance of the paper; in fact, it gives a very pleasing result viewed through a transparency—

Solution No. 2.—Ferrocyanide of potassium	. .	½ oz.
Distilled water	. . . . .	20 ozs.

When the image is fully developed, remove the picture to another vessel having clear water in it, and wash away the soluble salts remaining, continuing the washing until the paper is clear, and then dry it.

No fixing is required, and it may remain without being mounted unless desired.

If the paper, after being sensitised, has more than a small amount of light admitted to it, there will be a difficulty in removing the waste salts.

Some prints of equal excellence, possessing a velvety black tone, are produced by means of a final immersion in a solution of the chloride of platinum, and other tints by various other solutions.

PHOTOMETRY, GAS. *Standard Burners.*—The greatest difficulty in the way of adopting any uniform system of gas photometry, was the determining the kind of burner with which the gas should be tested. In England, since 1852, the Parliamentary standard of comparison had been a sperm candle of six to the pound, burning at the rate of 120 grains per hour. But Mr. WILLIAM SUGG, in a paper read before the Institute of Civil Engineers, assures us from his own examination that the average

normal rate of the burning of those candles was nearer 130 grains than 120 grains, therefore it was desirable that the Parliamentary standard should be altered if possible.

In 1863 Dr. Letheby and Mr. W. Sugg, finding that they obtained different results with different burners, adopted a standard burner, with a 15-hole incorrodible steatite top. This burner, known as 'the Sugg-Letheby' 14-candle burner, was one of the Parliamentary standard testing burners for 14-candle gas, and was used with a chimney 7 in. long and 2 in. wide in England and other places. There are, however, two other Parliamentary burners for 14-candle gas: one described in the Birmingham and Staffordshire Gas Act of 1864, and the other adopted by the Gas Referees in 1869. This was the invention of Mr. Sugg, and was known as Sugg's 'London' standard Argand burner for 14-candle gas, and it was used for testing the gas supplied by the London companies.

The same standard quantity of the same quality of gas tested by these three burners showed very different powers of light, the 'London' burners evolving the greatest, and the Birmingham the least amount of light. The total difference was nearly three candles. There were three different Parliamentary standard burners for testing 16-candle gas, all to consume the standard quantity of 5 cubic feet per hour, viz. the 'Dublin' 16-candle Argand 15-hole steatite top burner, used with a chimney 7 in. long by 2 in. wide; the 'Dublin' flat flame 16-candle burner, and the 'London' standard Argand for 16-candle gas, to be used with a chimney 6 in. long and 2 in. wide. There was but one Parliamentary standard burner for consuming 5 cubic feet per hour of 18-candle gas—that described in the Leamington Gas Act—which was a modification of the 'Sugg-Letheby' burner, the central aperture being enlarged to supply more air to the richer gas. The 'London' 18-candle burner for the same quantity of the same quality gas gave an amount of light equal to about 2¼ candles more than the Leamington burner. There was a 20-candle burner, and for 27 up to 32 candle gas, it was the custom to make use of any kind of fish-tail burner, and to consume any quantity of gas at the option of the operator. For cannel gases there was no regularly authorised Parliamentary burner. Mr. Sugg has introduced a standard burner for all qualities of gas from 12 to 30 candles. This burner might be easily gauged and verified by actual trial against the Government standard burner. It was the Gas Referees' London Argand burner, with a chimney 6 in. or 7 in. long by 1¾ in. wide, producing a flame always 3½ in. in height. When used with 16-candle gas, it would burn 5 cubic feet per hour, with a 3-in. flame, the light from which would be equal to that given by 16 sperm candles of 6 to the pound. The quantities of different qualities of gas required to produce in burning a 3-in. flame, with this burner were, with—

12-candle gas	. . . . . .	6·6 cubic feet
14 "	. . . . . .	5·7 "
16 "	. . . . . .	5·0 "
17 "	. . . . . .	4·7 "
18 "	. . . . . .	4·4 "
19 "	. . . . . .	4·2 "
20 "	. . . . . .	4·0 "
25 "	. . . . . .	3·2 "
30 "	. . . . . .	2·7 "

The Gas Referees' standard burner had been used of late years as a standard light for testing various kinds of gas burners, and it has been found that the illuminating power, as well as the appearance of the 3-in. flame, has been always constant, notwithstanding considerable variations in the quality of the gas. The method for effecting a comparison was as follows:—

The Gas Referees' 3-in. flame burner having been fixed on a photometer in the place usually occupied by the standard burner, it was lighted, and allowed to burn off all the dead gas collected in the meter and fittings of the apparatus. Then a clean chimney was put on, and the height of the flame regulated by the usual micrometer cock and King's pressure-gauge to exactly 3 in. The quantity of gas per hour required to give this flame was then found, and a reference to the table would show the illuminating power of the gas. The result was the illuminating power of the gas in terms of the Parliamentary standard quantity of 5 cubic feet of gas and 120 grains of sperm candle. Every quality of gas tried upon this system would be fairly consumed, and a like quantity of gas would be designated by the same number of candles of illuminating power.

PHTHALIC ACID. Nitro-alizarin is converted into this acid by the action of nitric acid. See Alizarin.

PHYTOLACCA DECANDRA. The Pocan, or Virginian poke or poke weed, a branching herbaceous plant, with a smooth green, or sometimes a purplish stem. Its dark purple berries, called by the French *raisin d'Amérique*, contains a purplish red juice something resembling red ink, and hence it is sometimes called the red ink plant. This juice has been used for adulterating wine. See WINES, ADULTERATED. Consult the *Treasury of Botany*, by LINDLEY and MOORE.

PICROMERITE. So called in allusion to the *magnesia* present. It is found at Vesuvius among the salts produced by the eruption in 1855. DANA gives two analyses by REICHARDT of this mineral found at Stassfurt:—

	S	Mg	K	H	Cl
1. Stassfurt .	38·52	11·66	22·52	(26·39)	0·91 = 100
2. " .	39·74	10·40	23·28	26·87	0·28 = 100·57

See KAINITE. *A System of Mineralogy*, by JAMES DWIGHT DANA, 5th edition, 1874.

PITA. (*Agave Americana*). Pita fibre and pita thread are names for the fibre obtained from this plant. It is also called *Aloe fibre*. See TEXTILE MATERIALS.

PIT CAGES, *loaded and unloaded by hydraulic pressure.* See COALS LOADED AND UNLOADED BY HYDRAULIC PRESSURE.

PITTICITE. A mineral, to which this name has been given, was obtained from one of the mines near Redruth, and examined by Mr. A. H. CHURCH.—*Chemical News*, xxiv. p. 19.

PLANING OF METALS. M. TRESCA has been for some time engaged in a series of experiments on the phenomena exhibited during the planing of metals. An account of his researches was published in the *Bulletin de la Société d'Encouragement*, from which we translate the conclusions at which M. TRESCA has arrived:—

'1. The operation of planing produces, in the prism of matter cut by the tool, characteristic pressures and deformations, which vary according to the form of the tool and the thickness of the prism removed.

'2. These circumstances are more easy to define where the case is that of a planing done over the whole breadth of a solid by means of a tool with straight edge, and cutting surface, plane or cylindrical, in which the generating lines are perpendicular to the direction of the movement, and parallel to the surface of the solid planed. With these conditions the shaving detached is a transformation of the original prism, produced by diminution of length, in consequence of a transverse flowing of matter in the direction of the thickness of the shaving, under pressure of the tool.

'3. The co-efficient of longitudinal contraction depends on the degree of sharpness of the tool, the facilities it offers for disengagement of the shaving, but, above all, the thickness of the shaving removed. The co-efficient of reduction is smaller for thin shavings, because the flowing in the transverse direction is then rendered easier.

'4. The co-efficient of dilatation, in the thickness, is inversely as the co-efficient of reduction in the length.

'5. The co-efficient of reduction varied, in the whole series of experiments made, from 0·10 to 0·60, and we possess shavings of steel of more than a millimètre in thickness, for which it does not exceed 0·25.

'6. The surface of separation between the shaving and the block is always smooth, and is modelled on the cutting-face of the tool. The opposite face is always striated, and presents the appearance of a series of parallel waves, which are more salient, the thicker the shaving. These waves continue to the edge, where we find indications of a flow in width, limited to a very small extent, commencing at these edges. In fine cuttings the striæ, which are much finer, impart a velvety appearance to the whole surface.

'7. A circumference traced on the exterior face before planing is transformed into an ellipse, in which the relation of the two axes affords the measure of the co-efficient of reduction; but it is best to obtain it by operating with great lengths.

'8. When the deformations exceed certain limits, the shaving is split at intervals, and there is a disjunction in the directions in which lie the furrows of the waves.

'9. When the tool is blunted, the co-efficient of reduction diminishes, and the planing becomes more difficult.

'10. The cylindrical form of the tool is very favourable to the operation, and an examination of the deformations leads us to the conclusion that the hyperbolic form is the most recommendable.

'11. In virtue of the pressure exerted by the cutting face of the tool on that of the shaving, the latter emerges perpendicularly to the surface of the solid, thereupon turning round. Thin shavings become rolled up in the form of a cylinder with spiral base, the windings exactly covering each other. The radius of rolling increases with the thickness.

'12. When the generating lines of the cylinder which forms the side of the cutting-

face of the tool are inclined relatively to the plane of motion, the shaving, instead of being rolled up cylindrically, takes the form of the exterior surface of a screw with square thread.

'13. The lateral attachment of a conical shaving by one or other of its edges has no sensible influence on the result of the planing. The co-efficient of reduction remains the same, but the edges originally engaged are less round, and are even cut sharply in one part of the thickness of the shaving.

'14. When the dimension in thickness becomes comparable to the dimension in width, there is dilatation in both directions, and the shaving takes a quite particular form, of triangular section, which is readily reduced from certain geometrical considerations.

'15. The employment of a tool with curved edge gives rise to similar transformations, which are explained in the same way.

'16. From the geometrical point of view the formation of shavings may be represented in all its phases by geometrical traces, according to perfectly sure rules. In a first phase, that of driving back the matter not yet detached from the block, it acquires, in each of its longitudinal sections, its definitive dimensions in thickness and width. In a second phase, that of flowing, the shaving slides on the face of the tool, and acquires its definitive section. In a last phase the shaving escapes, turning round, according as the co-efficients of reduction imposed on its different longitudinal sections exert on them an influence more or less preponderant.

'17. With the rectangular tool, having equal angles, a shaving of square section is liberated in the bisector plane of the dihedral figure formed by the two faces removed, giving rise to a deformation more complex, but quite as plausible as that of ordinary shavings.

'18. With the tool having a curved edge the effects are of the same order, and bring to light the mode of driving back of a solid brought to the state of fluidity under the action of the exterior pressures to which it is subjected on one of its faces. The curve, which is produced at the limit of the two first phases of the formation, is quite characteristic, and leaves its impress on the originally free face of the shaving, under the form of curved furrows, which are reproduced identically the same throughout the whole length.

'19. In the shavings, the breadth is approximately determined by the chord which joins the extremities of the crescent detached at each passage of the edge.

'20. The convexity of the shaving appears generally at the thicker border, and there is no exception to this, save in cases where the relative sharpness of the tool exerts, on the thin parts, an influence strong enough to compensate that of the more favourable co-efficient of reduction corresponding to the thicker border.

'21. The pressure exerted by the tool is transmitted from transverse section to transverse section up to the limit of the zone of activity.

'22. It is the ruling character of this work, the hardest, as the softest, metals are subjected in all these deformations to common laws which establish, for all the matter experimented with, an identity hardly suspected, hitherto, in their mechanical properties, even beyond their limit of elasticity.'

PLATINUM. (Vol. iii. p. 584.) BRITISH COLUMBIA.—More or less platinum has been found in the streams of British Columbia associated with the gold.

NEW SOUTH WALES.—Native platinum is reported to occur with the gold in the Shoalhaven River, and in the Ophir gold district of New South Wales. Also in the form of small grains in Bendemeer.—ARCHIBALD LIVERSIDGE, *Minerals of New South Wales.*

An ore of this metal has been found at Bluff. It consisted of from 35 to 42 per cent. of platinum, magnetic oxide of iron, and an alloy of platinum, osmium, and iridium.

The imports of platinum, *wrought* and *unwrought*, in 1875, were—

	Ozs. Troy	Value
From Russia	144,900	£113,738
" Germany	6,070	4,475
" Belgium	17,232	11,906
" other Countries . .	3,032	2,000
Total	171,234	£132,119

PLATINUM ALLOYS. (Vol. iii. p. 587.) *Comportment of alloys under the action of the blowpipe:—*

Platinum and tin unite with violent deflagration and emission of light, when subjected to the action of a reducing flame, forming a hard, brittle, and infusible globule.

Platinum, zinc, and tin unite with violent action, throwing off long flakes of oxide.

Platinum and zinc, per se, do not combine, the zinc burning into oxide.

Platinum and lead unite quietly, forming a brittle compound.

Platinum and thallium unite quietly; the resulting globule is dark externally, grey internally, and quite brittle.

Platinum and bismuth unite quietly, or with merely slight spitting, into a dark brittle globule.

Platinum and copper combine quickly, though not very readily, into a hard, light-coloured, malleable globule.

(Some years since, the editor of this volume, at the wish of Sir HENRY DE LA BECHE and of the Master of the Mint, Professor GRAHAM, made a large series of experiments with the view of producing an alloy which should answer for soldiers' war medals, but be of such small commercial value that they could not be sold. Some of the alloys of copper, platinum, and silver appeared to answer the desired end. Medals were struck at the Mint, and deposited in the Museum of Practical Geology, where, it is believed, they still exist.)

Platinum and silver unite quietly, but not very readily, unless the silver be greatly in excess, into a white, malleable globule.

Platinum and gold unite quietly, forming (if the gold be somewhat in excess) a yellow malleable globule.

Preparation of Platinum.—The following method of preparing platinum is used at Heräus' works, in Hanau, according to Mr. J. PHILLIPS:—

The ore is dissolved in one part of aqua regia and two parts of water in glass retorts under a pressure of 314 mm. water. The solution is evaporated, and the dry mass heated to 125°, at which temperature the palladium and iridium salts are reduced to subchlorides. The solution, acidified with hydrochloric acid, is treated with sal-ammoniac, which throws down pure platinum sal-ammoniac, while iridium sal-ammoniac separates after evaporating the mother liquors. In the filtrate from the platinum precipitate the metals are precipitated with iron filings; the precipitate is freed from the excess of iron with hydrochloric acid, and again dissolved in aqua regia, and from the solution another portion of platinum and iridium salts is obtained. The spongy platinum obtained by fusing the platinum sal-ammoniac is pressed, then broken into lumps, and fused in a lime crucible with oxygen.

Most of the platinum, when brought into commerce, is not pure, but often contains as much as 2 per cent. of iridium, a mixture which renders the platinum more suitable for vessels. The other metals—palladium, rhodium, ruthenium, osmium, and iridium, which accompany platinum—are separated by evaporating the mother liquors, when the iridium separates out with traces of platinum. After allowing the concentrated liquor to stand, the precipitate is filtered off, and the solution, after diluting, precipitated with zinc. The precipitate is digested with hydrochloric acid, washed, and fused. Aqua regia dissolves from the mass the palladium and a small quantity of gold, leaving impure rhodium behind.

The solution is saturated with ammonia, and the palladium precipitated with hydrochloric acid. The residue left on dissolving the platinum, which is Russian platinum, amounts on an average to 8 per cent.—is fused, ground, and washed. The powder is fused with equal parts of borax and saltpetre, and after treatment with hydrochloric acid and water, the platinum metals remain behind. These are alloyed with double the quantity of zinc in a graphite crucible, and the alloy is freed from the zinc by hydrochloric acid. The mass is then treated with chlorine in tubes made of Hessian clay with glass receivers; in this manner iridium and osmium chlorides are obtained. From the residue left after fusing in a stream of hydrogen, ruthenium is extracted by fusion with caustic potash.—'Preparation of Platinum,' DINGL. *Polyt. Jour.*, ccxx.

The following is curious and important:—

In attempting to reduce platinum from chlorplatinate of ammonium by the use of comparatively weak caustic soda and alcohol, a yellowish-brown powder was obtained which still contained ammonia. This ammonia could not be expelled by the addition of more soda and boiling. When washed, dried, and ignited, it took fire and evolved dense white fumes having the smell of acrolein; and there remained in the dish the finest spongy platinum, which readily passed into solution in aqua regia. The nature of the platinum compound containing ammonia and chlorine is not understood.—Dr. G. VULPIUS, *Archiv. der Pharmacie.*

PLATINUM STILLS. SCHEURER-KESTNER gives the following results of observations upon the wear of platinum stills used in concentrating sulphuric acid made at Thann, in Alsace. A still in which 4,300 tons of acid were concentrated to 66° B.—94 per cent. acid, in two years lost 12·295 kilogrammes, or 2·859 grams per ton. The acid was impure, containing nitrous products; by adding sulphate of ammonia the proportion was reduced in the following year to 2·200 grams per ton. When the acid

contains sulphurous acid, and is therefore free from nitrous compounds, the loss of platinum is 0·925 gram per ton. The quantity of platinum dissolved does not appear to be affected by the small amount of hydrochloric acid contained in the chamber acid, as it is sensibly constant for any particular degree of concentration, whatever may be the impurity of the nitric acid or nitrate of soda employed. When the acid is brought to a higher degree of strength the loss is much greater than with acid of 97 to 98 per cent.; it was found to be from 6 to 6½ grams, and with 99½ to 99¾ per cent. was as much as 8·45 grams per ton. The latter result was verified by diluting a quantity of the acid produced and separating the dissolved metals, lead and platinum, by means of sulphuretted hydrogen, the precipitate being dissolved in aqua regia and the lead precipitated as sulphide, and the process repeated until pure sulphide of platinum was obtained. The quantity of platinum recovered corresponded to 8·380 grams per ton, thus proving that the metal is actually dissolved and not removed mechanically by the boiling acid. An alloy of platinum with 30 per cent. of iridium is less readily attacked than pure platinum, but the use of this alloy has been given up from its being more brittle than the pure metal.

PLUMBAGO IN CANADA. Plumbago or graphite is a very common mineral in the Laurentian rocks of Quebec and Ontario, occurring in the form of disseminated scales in limestones, gneisses, and other rocks, or in veins cutting these rocks. In the former case the beds are often so highly charged with it as to become workable, but the plumbago, as might be expected, is not so pure as that found in veins. The most important localities known are north of the Ottawa River, in the townships of Buckingham, Lochaber, and Grenville, but the mineral has also been found in the Laurentian country south of the Ottawa, in Bedford, North Burgess, North Elmsley, and elsewhere. At the locality in the last-named township, from which the specimens exhibited were obtained, the plumbago occurs mostly in a disintegrated quartzose rock, which passes into an impure limestone. No mining of any consequence was done here until 1871; but from that time until the summer of 1873 about 6,000 tons of 'ore' are said to have been taken out by the company (the International Mining Company of New York) and delivered at the works, half a mile from the mine, for 80 cents a ton. It was there stamped, and the plumbago separated from the rock matter by revolving buddles. The works are situated at Oliver's Ferry, on the Rideau canal, about 7 miles from the town of Perth. Since 1873 they have at times been in operation, working up the material on hand, although no mining has been done.

The Dominion of Canada Plumbago Company was formed in June 1875, with a capital of 100,000*l.* sterling, and has commenced operations on an extensive scale. The property of the company comprises 1,250 acres of land in the seventh, eighth, and ninth ranges of Buckingham. The country here is well timbered and watered, and the facilities for mining unsurpassed. The mines are about 15 miles from Ottawa. The plumbago is found in both beds and veins, the principal veins, so far as known, being on lot twenty-one in the seventh range, while the most important beds are on lot twenty in the eighth range. Some idea of the size of the masses of plumbago which can be obtained may be formed from the fact that one of the specimens exhibited weighs 4,870 lb. The works of the company are on the nineteenth lot of the eighth range of Buckingham, and include appliances for crushing, washing, dressing, &c. When in full working order they are expected to turn out about 4 tons of 'prepared stock' per day, suitable for crucibles, pencils, and stove-polish, as well as for lubricating, electrotyping, casting, and numerous other applications. Mr. W. H. Walker, of Ottawa, is the present manager.—*Laurentian.*

An attempt has been made (1876) to reopen the plumbago mine in Borrowdale, in Cumberland. A few pieces of very fine blacklead have been raised, and a few hundredweight of an impure mixture of it with clay. No plumbago has been sold, and the mine is abandoned (1877).

The imports of plumbago in 1875 were:—

	Tons	Value
From Germany	2,699	£46,966
„ Holland	473	7,795
„ Ceylon	3,553	47,999
other Countries	363	3,867
Total	7,088	£106,627

PLOTTING. See Dialling.

POLYCHROMY. A name given to a process of printing in colours, which has been attracting some attention of late years. See Printing in Colours.

PORCELAIN, CHINESE. The mixture of finely divided felspar with the kaolin is effected by crushing briquettes of the two substances in large mortars, washing the powder with water, and decanting the latter. For fine porcelain equal parts of the raw materials are mixed, for inferior qualities an excess of felspar is generally used. The mass is rendered suitable for forming after being left to disintegrate for a long time (SALVÉTAT says sometimes for 100 years), by very careful kneading, treading, and beating.

In China the porcelain mass is not heated before the glazing operation. The composition of two burnt glazing masses gave—

Silicic acid	68·0	64·1
Alumina	12·2	10·2
Oxide of iron	traces	traces
Lime	14·0	21·0
Alkali	6·0	5·1

The painting of porcelain articles must be effected before the glazing operation takes place. For this manganese ores containing cobalt or preparations of cobalt are used. According to SALVÉTAT, a blue ore from Yunnan contained—

Silicic acid and insoluble residue	37·45
Oxide of copper	0·44
Alumina	4·75
Oxide of cobalt	5·50
Oxide of manganese	27·50
Oxide of iron	1·65
Lime	0·60
Magnesia, arsenic, and nickel	traces
Loss by ignition	20·00

Chinese Crakleware.—The minerals designated as Hoachy are partly impure fatty clays, used for *pâte-sur-pâte*, partly rocks rich in magnesia, which, when added to the glazing substances, yield articles covered with a dense net of small cracks. The furnaces used for burning are 3·15 m. high and 3·15 m. wide, 6·30 m. long, with a chimney 6·30 m. high; the time required for burning is said to be from 8 to 3 days.

Besides the blue colour above mentioned, various other colours are used for decorating purposes. The following are the principal colours and their composition:—

Ivory white	Oxide of lead, silica, and arsenic.
Black	Manganese, cobalt, oxide of copper and lead.
Blue	1. Fluorspar with cobalt. 2. Fluorspar with copper.
Yellow	Antimony.
Green	Antimony and copper.
Red	Oxides of lead, iron, and fluorspar.
Carmine	Gold with fluorspar.
Pink	Oxide of lead, silica, arsenic, felspar, and gold.

'Chinese Porcelain Manufacture,' by A. HEINTZ, DINGL. *Polyt. Jour.* ccxxi.

Porcelain, Toughened.—It has been proposed to toughen porcelain and enamel in a similar manner to that used for toughening glass. See GLASS, TOUGHENED.

PORTUGAL BERRIES, used in colouring wines; for the detection of this colouring matter, see WINES.

PORTLAND CEMENT. Since alkaline carbonate is often added in the grinding-mills, in order, by the introduction of carbonic acid, to cause it to harden more slowly, calcined soda is, however, more frequently used; the volume of the cement remains unaltered, just as when water alone is added, but the rapid absorption of the water and the intensity of heating is moderated. The addition of the alkali before burning, as well as during the grinding, renders the cement more suitable to retain the water necessary for hardening.

Portland cement often falls to pieces in burning. If clay is added, this is, to a certain extent, prevented. Lime will also modify this defect.

It is recommended that a small quantity of raw calcined soda, about 5 per cent. or less, provided the mass of cement is finely divided and well mixed, should be used to bring about an excellent result.

'Judging,' says Dr. ERDMENGER, 'from the chemical composition of Portland cement (¾ the silicate of lime and silicate of alumina), we theoretically require only lime and clay. The poorer in alkali the raw material is, the more soda is required,

while with raw material rich in alkali it is not at all needed. For preparing cement on a large scale, clay, lime, and ½ to 1½ per cent. of alkali are required.

'LIPOWITZ (*Die Portland Cement Fabrication*) long since pointed out the advantage of using soda.'—Dr. ERDMENGER: DINGL. *Polyt. Jour.* ccxviii.

POTASH. (Vol. iii. p. 591.) A process for obtaining alkali from seaweed has been published in the *Chemical News* for November 10, 1876:—

'At the chemical works at Aalborg, in Jutland, Denmark, where about 30 tons of alkali are made per week by the ammonia process, Mr. THORWALD SCHMIDT, the director of the manufactory, proposes to work, in conjunction with this process, a method devised by himself of treating seaweed so as to obtain iodide, potash salts, and other marketable products therefrom. In Denmark a very heavy duty is levied on the importation of common salt, whilst enormous quantities of seaweed rich in iodine and potash can be obtained at small cost in the neighbourhood of the works. Mr. SCHMIDT's process is as follows:—After the seaweed is dried and burnt a concentrated solution of the ash is made and added to the liquor, containing chlorides of sodium and calcium, left after the ammonia has been recovered in the ammonia-soda process by boiling with lime. The sulphates of potash, soda, and magnesia contained in the ash of the seaweed are thereby decomposed, and hydrated sulphate of lime and hydrated magnesia are precipitated in a form which may be available for paper-making as "pearl hardening." The last traces of sulphates are got rid of by adding a small quantity of solution of chloride of barium. To the clear solution nitrate of lead is now added, until all the iodine is precipitated as iodide of lead, which is then separated by filtration and treated for the production of iodine or iodides. After filtration the liquid is boiled, nitrate of soda is added to convert the chloride of potassium present into nitrate of potash. The latter is separated by crystallisation. There remains a solution of common salt containing traces of ammonia from the previous soda operation and a trace of chloride of potassium. This solution is again treated by the ordinary ammonia-soda process for the production of bicarbonate of soda and white alkali.

Within the last twenty years potash has been obtained commercially from—

1. The carbonised residue of beetroot molasses.
2. The washing of sheeps' wool residues.
3. The deposit of potassium salts at Stassfurt.

H. GRUNEBERG has devised a method by which the chloride of potassium of the Stassfurt deposit, by double decomposition with sulphate of magnesium, is converted into sulphate of potassium.

1. By the action of a hot solution of sulphate of magnesium upon the chloride of potassium—

$$3KCl + 2MgSO^4 = MgSO^4K^2SO^4 + KClMgCl^2.$$

2. By treatment of the hot solution of the above double salt with chloride of potassium, or by macerating the undissolved double salt with a cold solution of chloride of potassium—

$$K^2SO^4MgSO^4 + 3KCl = 2K^2SO^4 + KClMgCl^2.$$

3. Decomposition of the double salt, KCl Mg Cl^2, by maceration with cold water.

MINERAL SALT DEPOSIT AT ASCHERSLEBEN.—Extracts from the report of the Right Hon. LYON PLAYFAIR, C.B., M.P., chairman of the board of directors of the CONTINENTAL DIAMOND ROCK-BORING COMPANY, Limited, as to an inspection made by him of the borings of Aschersleben, in Germany.

'As it was important, in the interests of the shareholders of the CONTINENTAL DIAMOND ROCK-BORING COMPANY, that I should inspect the borings in progress near Aschersleben, I went there last month with Mr. SCHMIDTMANN, the Continental managing director. These borings are not like others, made on contract, but are speculative. In the dull state of trade there was not sufficient demand for our machines, and the question was whether they should remain idle or be employed in prospecting work on our own account. The Prussian mining law holds out inducements to such speculative work, because the finder of new minerals is entitled to a concession of 2,189,000 mètres square of the underlying minerals.

'The selection of the potash field of Aschersleben was excellent for speculative boring. It is in the neighbourhood of Stassfurt and Leopoldshall, at both of which places mines have been established in the potash beds overlying the rock-salt. The geological formations around seem to indicate that in former times there was a considerable salt lake which had dried up, the rock-salt being deposited first, and the more soluble potash-salts afterwards. The two main minerals are carnallite, or chloride of potassium and magnesium, and a less soluble mineral, kainit, chiefly a double sulphate of potash and magnesia. Kainit is to be expected at the outcrop of the lake

basin and carnallite more in its centre. Kainit is the most valuable mineral, but hitherto has been comparatively rare. It does not occur in the Prussian mine at Stassfurt, but it is found in limited quantity in the Anhalt mine of Leopoldshall.

'Mr. Schmidtmann showed much discretion in first trying for the outcrop salts. It was necessary to know the limits of the basin, otherwise our subsequent operations might have been interfered with by other borers, brought into the field by our success.

'Accordingly, No. 1 bore was put towards the supposed edge of the old salt lake. It was happily successful. The deposit of potash salts was found at a depth of about 835 feet, and proved to be above 60 feet thick. It consists of the kainit bed, with not inconsiderable quantities of sylvin (nearly pure chloride of potassium) and boracit, a valuable mineral which supplies boracic acid, but hitherto found only in nodules. In this bore boracit was in unusual quantity, though this may have been due to the accident that some nodules of this mineral happened to be in the line of the bore-hole. The evidence as to the thickness of the kainit was not conclusive. It may be thicker, as the solution obtained from the boring became vitiated by using chloride of magnesium (which was subsequently found to contain potash) in the water required for the later stages of the boring operations. This was done in the hope of extracting solid cores, by saturating the wash water with the view of preventing the solution of the minerals. Below the potash layers our bore proved the existence of a bed of rock-salt, no doubt of great thickness, but this, in the presence of the more valuable potash-salts, need not be taken into consideration.

'No. 2 boring is about 4,000 mètres from No. 1, and still nearer the supposed outcrop. It may be, in reality, outside it, but that information will be of value. Still, I think, from the nature of the ground, it may be found to be just inside the basin. We may expect that kainit will be found also in this hole, probably not quite so thick as in No. 1; but, at my suggestion, paraffin oil, or petroleum (in which the potash minerals are insoluble), will be used, instead of water, to clear the bore-holes, and in this way we may get solid cores of the salts for examination. In the case of No. 1 the evidence was mainly dependent on the analysis of the wash water, and on small fragments of solid salts brought up with it. To my mind the evidence is quite conclusive, and it is accepted as such by the Prussian Government; but it will be still more complete if we can get solid cores by the use of petroleum.

'No. 3 boring has been fixed at 4,000 mètres more towards the centre of the basin. The depth here to the salts will be greater, but the thickness of the potash bed will probably be much more than in No. 1 and 2. Most likely we will find ourselves in carnallite, not in kainit. This is to be desired, because, though that mineral is less valuable per ton than kainit, it exists in much larger quantities, and is the chief source for the manufacture of chloride of potassium. There is a difficulty in this boring. No water to work the machine is to be got in the neighbourhood. Accordingly, Mr. Schmidtmann has begun by sinking a well. It is now 95 feet deep, and the water is not yet sufficient. But, as the cost of sinking is not much more than that of boring, this is of little consequence, beyond the delay in proof. The boring here is not yet begun. I think, however, that the site has been well chosen.

'In addition to inspecting the borings in this field I also visited our central offices at Leipsic. In all the cases I was much pleased with the excellent organisation of the work. Mr. Schmidtmann's whole soul is in it, and the business-like method of his organisation is admirable. His engineers and foremen have caught his spirit and work with fervour, and, at the same time, with caution.

'To return to the potash field of Aschersleben. I think there cannot be a doubt that the company, by this speculative boring, have secured a property of great value. I have not seen any accounts of profits from the Prussian mine, but those of the Anhalt Government are laid before the local parliament.

'The expenditure of the Anhalt government, close to our borings and in a similar field, in sinking and establishing their pit, may be estimated at 45,000*l*., and I am informed that they make nearly double that amount per annum of clear profit. In 1871 they were offered 7,500,000 thalers (1,125,000*l*.) for its purchase, and refused the offer. There is no reason to suppose, if we find carnallite, as I expect, at No. 3, that we have a less valuable field of minerals, for then we will be in exactly the same circumstances of the kainit and carnallite regions as the Anhalt Government, and at the junction of two railways leading to all parts of Germany, and in the neighbourhood of a large field of brown coal.

'The conclusion, then, to which I have come by my inspection, is that we have been amply justified by results in this speculative boring, and that we owe much to the energy and discretion of Mr. Schmidtmann. We must be prepared to undertake still further borings in the same field, because we must secure the whole of it to prevent competition. Not that we require more mineral for practical work. If borings Nos. 2 and 3 come out as we expect, there is enough in our hands, and belonging to

us, for mining for a long period; but the expense of boring is so little compared with the result, that we must secure ourselves against other competitors by proving, and thus appropriating, the remainder of the field. This being done, there will be only three proprietors besides ourselves in the field. They are the Prussian and Anhalt Governments, and a Mr. DOUGLAS, who has found the salts in an unfavourable position 12 miles from a railway, but who has offered to sell his concession, mine, and chemical manufactory for 725,000*l*. The Prussian and Anhalt Governments have simply mining establishments to extract the minerals, and these are sold to about thirty private chemical works which have arisen in their neighbourhood entirely to work them into saleable products.

'Mr. SCHMIDTMANN and I saw the officials of both Governments, and pointed out how advisable it would be for us to combine and regulate the market, instead of fighting with each other. They at once admitted that this would be to their interest.

'In order to work this concession properly 150,000*l*. would be requisite for the purpose of sinking pits, erecting chemical works, and for providing working capital. It would require about two years before the pits and works could be in full activity.'

PRESSURE OF GAS. See VARIATION OF PRESSURE.

PRINTING. (Vol. iii. p. 629.) PRINTING MACHINES, vol. iii. p. 653. Although some of the machines described in the previous volume have been slightly modified, there does not appear to be anything of sufficient novelty in connection with these to require special attention. A few new machines must be noticed.

The 'Victory' printing and folding machine, manufactured by the VICTORY COMPANY, of Liverpool, has many advantages, of which the following are the most remarkable.

The special merit of the machine is that it not only prints, but folds the newspaper worked upon it. The necessity for such a machine has long been felt by provincial newspaper proprietors, since the usual custom out of London is to issue newspapers to the trade ready folded. Even in London, too, it is becoming the fashion to fold evening papers before selling them. In provincial offices, therefore, and here and there in metropolitan ones, folding machines are employed in addition to printing machines, manual labour being almost out of the question when immense numbers of papers have to be folded in a very brief space of time. The 'Victory' machine was therefore designed for performing both printing and folding simultaneously. The first of these machines was erected in May, 1870, and the second in December following, in the office of the *Glasgow Star*. In the course of 1871 another was erected, also in Glasgow, for the *North British Daily Mail*.

It is hoped that the following description may render the construction of this machine intelligible:—

The roll of paper, which may be as long as four miles, is unwound, and passes over a roller, one side of it being wet by the spray from a row of jets of water striking an inclined plate. Passing again over the web, it is wet on the other side by a similar arrangement, and this goes on until it travels around and between two copper cylinders, which are warmed by steam, so as to distribute the moisture and promote its absorption by the paper. The web then passes between the first type cylinder and its impression cylinder, by which the inner forme is printed, then receiving the impression of the outer forme by means of the second type cylinder and its corresponding impression cylinder. The inking arrangements are above the type cylinders. The paper then passes on to the folding cylinders, by which it is cut across its width, and at the same time in the direction of its length by a small circular knife. The cut across is effected by a straight serrated knife working into a groove in a cylinder. The sheets thus produced receive their first fold (in the 'heads') in the direction of the axis of the cylinders which carry them; the second fold (down the 'back') is given by a bar, after which the folded papers run up each side of the machine and are dropped in a regular pile. A counter indicates the number of copies worked. This machine at the *Globe* office is supported by girders resting upon columns. It weighs about 10 tons, its dimensions being: Length, 18 ft. 7 in., including the roll and delivery flies; breadth, 7 ft.; height, 6 ft. 10 in.

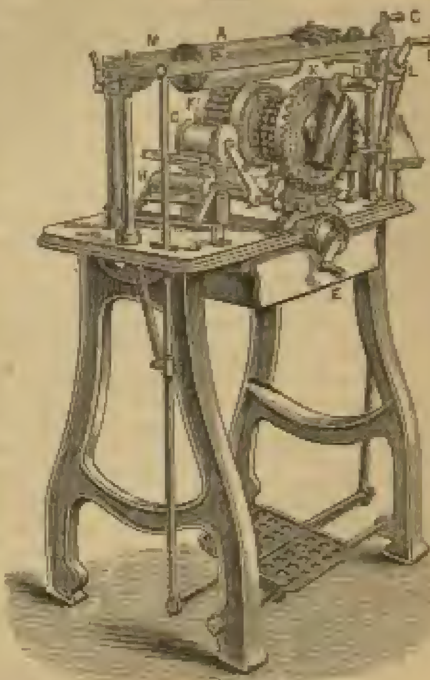
Alisoff's Mechanical Printer.—The machine invented by M. MICHAEL ALISOFF, of St. Petersburg, has recently attracted much attention. It has been exhibited at Vienna, in Philadelphia, and in the CAXTON Exhibition. The following drawing and description, for which we are indebted to the proprietors of *Iron*, will convey a very perfect idea of its construction and mode of action.

The apparatus is about the size of an ordinary sewing machine, which it resembles as far as the stand, table, and treadle are concerned. The treadle, however, is used for drawing down a cylinder, A, carrying the paper on to a revolving drum, F, on the circumference of which the types are fixed. The printing takes place in a direction at right angles to the axis of the paper cylinder, one revolution of which corresponds

to a line of characters on the paper. The same action also gives the feed in two directions, besides performing other operations.

On the table or bed-plate are fixed a pair of pillars with the adjustable conical centres, on which works the frame carrying the paper cylinder. This frame is drawn down by the treadle acting through the side rods, so as to bring the paper cylinder down upon the type-drum, F, which is normally held clear of it by means of spiral springs at the sides. Two other pillars, with leather washers on the top, limit the stroke of the frame, and stops are provided for preventing the frame rising higher than necessary.

2453



The type-drum is fast on a spindle mounted on a slide which works in V guides, like the slide-rest of a lathe, and may be moved in and out by means of the handle, E, shown in front of the machine, one complete revolution of the handle bringing a different 'fount' of type into position for printing. The revolutions are easily counted through the clicking of a spring which engages in a notch in a disc fast on the screw spindle. Six rows of different types are fixed by set screws in grooves in the drum, F, and a handle, D, fast on the spindle, serves to turn the drum so as to bring uppermost any one that it may be desired to print. A fixed dial in front marked with the different types and signs, like that of a WHEATSTONE telegraph transmitting apparatus, serves to show which row of type is brought uppermost. As two cylinders at right angles to each other only touch at one point, so only one letter can be printed at a time. Between the type-drum and the dial is an intermediate cylinder with six rows of screws, projecting more or less, according to the width of the different types.

The inking of the types is effected by the type-cylinder in its revolution, turning the ink-roller, G, on the left, which takes its supply from another roller, H, which, in turn, takes it from a narrow disc. This disc is calculated to give just enough ink at a time, which it takes from a long roller, whose bearings are capable of sliding in and out so as to present a fresh surface to the disc when required. There is also another roller on the right of the type-drum for taking the surplus ink off the type.

We have said that the treadle and side rods give the feed motions. The drawing down of the paper-cylinder frame turns, by means of a pawl, a ratchet-wheel fast on a spindle at right angles to the paper-cylinder, and causes it to make part of a revolution after each letter or sign is printed. Between the type-drum and the feed-spindle, which may also be turned by a handle fitted on its square end, for arranging on the paper the matter to be printed, are the bearings of a lever. One end of this lever carries a stop, adjustable by a screw, which strikes against the projecting screws on the continuation of the type-drum. The other end carries a rod with a pawl at the end, which by an ingenious mechanical arrangement throws off the pawl from the feed ratchet-wheel as soon as sufficient travel is given to the paper-cylinder for the width of the particular letter that has just been printed.

On the top of the frame, and parallel with the paper cylinder, works a screw in bearings, for causing the paper cylinder to travel along its spindle, thus giving the desired amount of space between the lines. This is turned by a handle, C, at the end, and a disc with a notch and spring facilitates the counting of the turns.

A warning of the near approach of the end of the line is given by a bell, the hammer

of which is caught by a projection on the collar of the paper-cylinder spindle. This collar can be adjusted on the spindle with a set-screw, so that the bell may sound at any given distance before the end of the line. An index on the cross feed-spindle, pointing to a dial divided into 100°, also enables the operator to arrange the writing on the paper, as in the heading of a business letter, &c.

Though this machine is not intended for original composition, it will produce a well-printed copy in rather less time than is required to make a fair copy by hand; and this copy will yield two or three duplicates by being simply passed between rollers attached to the machine. If more are required, the first copy must be printed on prepared paper, and transferred on to stone, as in ordinary lithography, when any number of copies may be printed off. The machine will be of great use in large establishments, where the principal is in the habit of dictating the letters to a shorthand clerk. The clerk would soon learn to print at once from his notes, and thus save a great deal of time, as well as produce clearer transcripts, for it is well known that the ordinary handwriting of stenographers is not very legible.

This machine affords, in fact, a printing establishment on a small scale, and on the premises—one which can be brought into use without any skill in composing, without much space, stock of type, or dirt; and which, at the same time, furnishes printed copies of any document at a much cheaper rate than letterpress printing, if the number of copies is limited. It possesses this further advantage, that all documents are printed in the office itself, thus insuring independence of the printer, secrecy if necessary, and also saving of time, as the first lithographed circulars may be sent out within an hour from the time they were written. The machine is capable of holding at one time all the types necessary to print two different styles of capitals and small letters, as well as figures and fractions and all the usual signs, so that two languages—for instance, Russian and English—may be printed by the same machine.

In conclusion, we may observe that there is nothing in the manipulation, either of the machine or of the lithographic process, that cannot readily be picked up by any intelligent office lad in a short time, and that no amount of carelessness will prevent all the copies from being fac-similes.

PRINTING, BLOCK. (Vol. iii. p. 651.) Mr. PETER MARTIN SHANKS patented in 1874 'Improvements in the Production of Raised Surfaces or Blocks for Printing, and in the Preparation of Materials, and Construction of Apparatus employed therein.'

This invention possesses much of the character of JORDAN'S wood-carving machine (see CARVING BY MACHINERY, vol. i. p. 738), but it is here employed for the purpose of producing raised surfaces or blocks for use in ordinary letter-press printing, and for other similar purposes.

In preparing blocks for surface printing it has hitherto been usual to produce in the first place a matrix having hollows in its surface corresponding to the parts which are to be raised in the block, and to use such matrix as a mould for casting or electrotyping the block. Mr. SHANKS, in his specification, thus describes his invention:—

'Instead of any of these methods, according to the present invention, a drill or conical cutter, made to revolve rapidly, is employed to cut out the hollows of the matrix, its action being guided by means of apparatus which will hereafter be described.

'The material employed to form the matrix should be such as to be capable of being moulded or cast into blocks of the required size, of being easily and yet cleanly cut by a revolving tool, and of withstanding the heat to which it is subjected when the printing block is cast upon it in the manner of a stereotype.

'In order to fulfil these conditions, china clay, or other finely-divided earthy substance of like character, may be compressed into a mould, or a mixture of china clay with starch or powdered gum, the moulded block being dried before engraving.

'One of the most suitable materials is plaster of Paris prepared in the following manner:—Dehydrated plaster of Paris being mixed with water in the ordinary way, is cast into a mould and allowed to set. The block thus produced is dried in an oven, which may be heated by hot water or steam pipes to a temperature not exceeding 200° Fahr., about 160° being the most suitable temperature. The block, when thoroughly dried, is immersed in an alcoholic solution of shellac, and when saturated with the solution it is taken out, wiped, and dried in the oven. The material, thus impregnated with the resinous gum, is fit to receive a clean incision.

'For many purposes wood, such as is used for engraving, may be employed to constitute the matrix block.

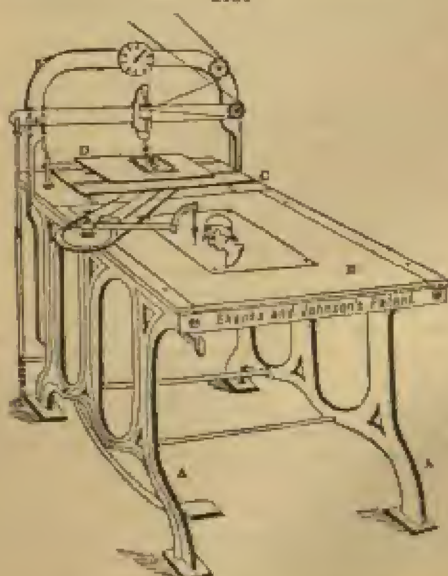
'The apparatus for engraving the matrix block consists of a movable table, on which the block is laid under a rapidly revolving drill or conical cutter mounted vertically above it. The drill is raised or lowered by a lever, screw, or other gear, so arranged that its downward movement can be varied and delicately adjusted to give the desired depth of cut, and that it can be rapidly drawn upwards out of its cut by a cam or treadle.

'The matrix table is mounted so as to run or slide freely in one direction on a frame or table, which is itself mounted so as to run or slide freely in a direction at right angles thereto, whereby any part of the matrix block can be brought under the drill. On a table near the matrix table is fixed the design to be copied, and a pin projecting downwards from the matrix table is connected in the manner of a pantograph or eidograph with a tracing pin, which can be guided by hand along the lines of the design. The scale of the copy can be varied by altering the proportions of the pantograph or eidograph arms. Thus the block is moved in accordance with the copy, so as to bring the proper parts of its surface under the drill, which cuts the lines therein to a depth depending on the vertical adjustment of the drill.

'For greater facility in guiding the tracing point, the design may be engraved, stamped, or pointed or sunk in gelatine or other suitable material. On the matrix block thus prepared the printing block is moulded, either by casting it as a stereotype, or by depositing it as an electrotype.

'The preparation of printing surfaces in the manner described affords facilities for printing music, or for altering maps to show strategical movements or other variations of indications upon it. For printing music, for example, a cast may be taken from some of the characters, such as the lines, clefs, and other constant marks, the notes, ties, and other varying marks being subsequently cut thereon to form the matrix. For a map to show strategical or other variations, as, for example, meteorological indications, a cast may be taken of the outline map and its standing matter, and the varying figures or other symbols or marks can afterwards be cut in it. In copying such variations the original map or design to be copied, and the matrix block to be engraved, are fixed in correct register with one another. The variation of the map or design being either drawn upon it or on a sheet of tracing paper, talc, stout gelatine, or other sufficiently transparent substance fixed on the map or design, the tracing point can be guided along the lines of the variation, so as to cause the corresponding cuts on the matrix to be effected by the revolving drill.

2454



'*Fig.* 2454 represents an eidograph apparatus adapted for copying a matrix to be used in the manner above described.

'A is the framing of the machine, supporting a table B, on which is placed the article to be copied. C is a plate mounted on rollers running in grooves, so that it can be freely moved to and fro longitudinally, and D is another plate mounted on rollers running in grooves, so that the plate D can be freely moved to and fro transversely on the plate C. The matrix to be operated on is fixed on the plate D. A lever, mounted to oscillate horizontally on a pin, carries at its opposite ends two

equal pulleys connected by a strap, which may be of thin steel or other metal, and which, as the pulleys do not require to be turned more than half a revolution, may be fixed at a point to the periphery of each. On the axis of the one pulley is fitted a slide carrying a tracing point, which is carefully moved by hand over the outline to be copied.

'It may be readily understood that the floating table or plate of the apparatus described, instead of being guided by the eidograph action, may be moved in the manner of a slide-rest, by means of screws when it is desired to engrave by the revolving drill a matrix to the same scale as the copy, or when the outlines of the intended matrix are drawn upon the block that is to form the matrix. And in this manner a printing block may be formed without a preliminary matrix, by applying the revolving drill to cut out the hollows of such block, leaving the printing surfaces standing. Or only the larger hollows of such printing-blocks may be thus cut out, the more delicate lines being separately engraved or touched when necessary. In employing the apparatus in this manner, it is convenient to mount the two movable plates described on a circular rest, which may be worked by worm gearing, so as to give a circular as well as a longitudinal and a transverse movement to the block operated on.'

Mr. Shanks, in conclusion, claims—

'First. The method substantially as herein described of preparing a matrix for the production by casting or electrotyping thereon of a printing block, the required hollows constituting the design in the matrix being cut by a drill or revolving cutter, while the matrix itself is guided proportionally to a tracer following a copy.

'Second. The use for the materials of a matrix to be prepared in the manner above referred to, of finely-divided earth substance compounded or impregnated with starch, gum, or resinous matter, substantially as herein described.

'Third. The use for preparing a matrix in the manner above referred to, of apparatus consisting of a drill or revolving cutter, which can be made to enter the matrix to an adjustable depth, in combination with a table on which the matrix block is fixed, such table being guided so as to move proportionally to a tracer following the lines of the copy, substantially as herein described.'

Frazer's *Composing Machine.*—Mr. Alexander Frazer, of Edinburgh, informs us that after examining the machines exhibited in 1862 for composing and distributing type, he felt sure that the time was approaching when the composition and distribution of type would be performed by machine, and he gave considerable attention to the subject. A machine introduced by Mr. Hattersley was the nearest approach to a good practical one. Having possessed himself of one of these composing machines, Mr. Frazer set himself to work to improve it, and to produce a new distributing machine. The result was the production of the machines now in use.

The plan of the machines will be understood by reference to the illustrations. *Fig.* 2455 is a general view, and *fig.* 2456 a section of the composing machine. The types are contained in grooves in the trays, A, which have previously been filled by the distributing machine. The lines of types are pressed towards the front end of the trays by slips of metal attached by cords to the box wheels, B, each of which contains a spring of sufficient strength to press the line of types steadily forward against the pusher, C, the front type being over an aperture in front of the tray, through which it is prevented from falling by the pressure of the spring behind. The separators or pushers, C, are formed with an inverted shoulder, extending sufficiently backwards over the type to act on one only when moved downwards. The keys of the keyboard, D, are connected by cranks, E, to the pushers, and the depression of any key, therefore, causes the corresponding pusher to descend, carrying with it the front type of the line into the grooved face-plate, F, down which it slides into the composing-stick, G. Immediately the finger is lifted from the key the spiral spring, N, above the pusher, raises it to its original position, and the next type in the line takes the place of the one just released. Under the row of cranks, E, there is a cross bar, H, to which is attached a wedge-shaped pusher, I. This, on the depression of any key, acts upon a slide, K, which pushes forwards the types as they reach the composing-stick, and thus makes room for the next letter.

The great diversity in thickness of the different letters of the alphabet, ranging from the small letter 'i' to the capital 'W,' has to be provided for. For this purpose the pushers are divided into four sets, each set with a different depth of shoulder for receiving the type according to its thickness. The aperture in front of the tray, through which the type is carried by the pusher into the face-plate, is also regulated to suit the different letters, so that only one letter can pass to the face-plate with each depression of a key. The grooves in the face-plate are made of different depths to suit the different letters, and the whole covered with glass, closely fitted to the face plate, to prevent the types passing from one groove to another, and also to

prevent their turning over, or round, when descending. The letters are so arranged in the trays that the thin letters are in the centre of the plate and the thick towards

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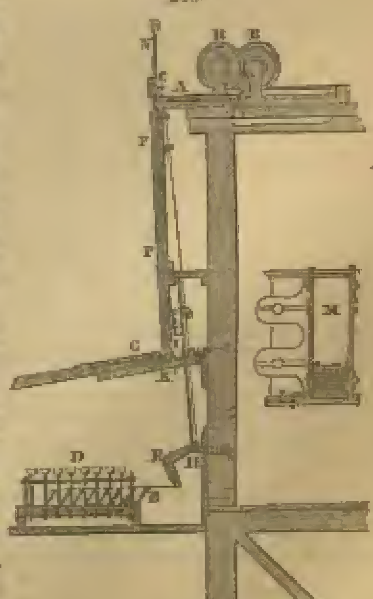
the outside. The object of this is to insure that each letter reaches the composing-stick in the order in which the keys are depressed, however fast they are touched. Were the thick letters in the centre and the thin towards the outside, the greater gravity of the thick types, combined with the shorter distance to travel, would, in rapid setting, cause a thick type to reach the composing-stick before or at the same moment as a thin type released immediately before it. As all the grooves converge to one opening, through which thick and thin letters have to pass, a movable tongue, L, is introduced, which is kept in position by a small lack weight. The aperture between the tongue and glass is made wide enough for the thin types to pass through, and the weight of the thick types in descending is sufficient to press back the tongue and thus enlarge the aperture to the extent required to allow them to pass.

2456



There are two kinds of composing-sticks, which, being made to fit the same holder, are exchangeable at pleasure. The long stick, D, is, for reasons given above, most suitable for newspaper or general book-work. For tables, that is, matter consisting wholly of figures and spaces, the short stick, M, is specially valuable, as in such matter no spacing out of the lines being required, the tables are at once set to the proper

width, the rules dividing the columns being afterwards put in by hand, as at present.

The composing apparatus, it will be seen, is comparatively simple. The types being already arranged in lines in the machine, all that is required is to release the letters wished, and they immediately, by gravity, aided by the impetus they have received in starting, find their way by means of the grooved face-plate to the composing-stick. It is, however, different with the distributing machine. In it the types, thick and thin, have all to start from one point, and before reaching their destination have to be separated and sent into nearly a hundred different compartments, and there set up in lines, each letter by itself. This is effected by means of a series of switches acted upon by mechanism in connection with the keys, the depression of a key being all that is required to separate the type from the line and guide it into its proper position in the composing machine trays.

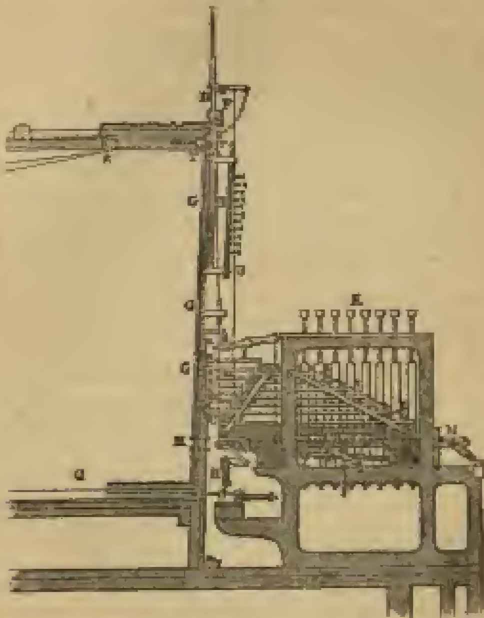
Frazer's *Distributing Machine.*—*Fig.* 2457 is a general view of the distributing machine, showing the face-plate, with switches, and grooves down which the types slide to the composing-machine trays. *Fig.* 2458 is a section showing one of the sets of keys and levers for moving the switches. From *fig.* 2457 it will be seen that there are three sets of switches. The first or stop switch, A, separates the capitals and figures from what are technically called lower-case letters. The next series, B, divides these two into twelve sections, separating the thick from the thin letters; and the lowest series, C, divides each of the twelve into eight, making in all ninety-six different letters, points and spaces. The keys are so arranged that each section of eight consists of letters of nearly the same thickness.

2457

The page of type to be distributed having been placed on the galley, D, it is pushed forward by a small rack and wheel until the front line drops into a groove, along which it is propelled by wheel and cord, E, in the same manner as the lines of type in the composing machine, until the front type is pressed against the separator, F, at the end of the groove. Several lines having been thus placed in the groove so as to form a continuous long line, the matter is ready for distribution. G, *fig.* 2458, is an edge view of the grooved face-plate containing the switches, of which the front view is shown in *fig.* 2457. The switches, A, B, C, are double, having front and back portions joined, as at H, by hinges passing through the face-plate, so that on any one of the back switches being moved, the corresponding front switch moves with it. These switches are actuated by levers, I, which are brought into action by the depression of the keys, K. One end of the levers passes through slots in the key-rods at L, while the other end is in contact with the back portion of the switches at M. On the depression of any key, therefore, the opposite end of the lever opens the switch with which it is in contact, and thus guides the descending type into the channel wished. In addition to opening its individual switch, each key-rod of a section acts, by means of a pin fixed to it, upon a bar, N, hung upon parallel levers, so that whatever key of

a section is touched, the corresponding section bar is equally depressed. These bars, N, are connected by cranks and wires to the middle series of switches, B, so that the

2453



depression of any bar opens the corresponding switch and guides the type into one or other of the twelve main channels. The upper switch, A, remains in position for all the lower-case letters, but is moved by similar mechanism to the opposite side on any of the capital or figure keys being depressed.

Under the sectional bars there is a transverse bar, O, and the depression of any of the sectional bars also depresses the transverse bar. This transverse bar rests upon a lever, P, to which is attached a wire connecting it with the separator. On the depression of any of the keys, therefore, the separator descends, carrying with it into the grooved face-plate, and thence into the composing machine trays, Q, the front letter of the line of types to be distributed. The types, as they reach the trays, are moved forward by wedge-shaped pushers, R, attached to the under side of the sectional bars, thus clearing the way for the next descending type.

To enable the machine to be worked with rapidity, a series of catches, S, is introduced, which hold each switch as opened till another key of the same section is touched. This gives time for the type to travel to its destination before another key is touched, which would not be the case if the switch resumed its former position on the finger being lifted quickly from the key. The key-rods and bars are kept in position by spiral springs placed under them, so that on the pressure being removed they at once return to their former position.

Another important function of the sectional bars is the regulating of the size of the aperture through which the types descend on being separated from the line. As already explained, the types are divided by the machine into sections of eight, each section consisting of types of the same or nearly the same thickness. The aperture, therefore, has to be made to suit the eight different thicknesses. Under the front types in the line is a small sliding valve, T, with projection in front, and against this projection there rests the upper end of a lever hinged at U. The mechanism for opening the B switches act at the same time on this lever, pressing it against the front of the sliding valve, and thus opening it to the extent required to allow the passage of the types into the face-plate and trays.

PRINTING IN COLOURS. OLEOGRAPHS, STENOCHROMY, CHROMO-LITHOGRAPHY (vol. iii, p. 124) has made us familiar with printing in colours. A method, peculiar in itself, simple in many of its details, and promising to lead to some

important applications, was first introduced to notice in 1874. Then the printing was effected from cakes of colour cut out and fitted together, much after the manner of a dissected puzzle. A modification of this process has been patented under the name of 'Stenochromy.'

STENOCHROMY.—The invention is now in the hands of M. OTTO RADDE, of Hamburg, who, though not the original inventor, claims the credit of having brought the process to its present degree of success. The specimens now in England are in the possession of Mr. MEYERSTEIN, of Fenchurch Street, who read a paper before the Society of Arts describing the new process. The specimens exhibited consist of reproductions both of oil and water-colour paintings, besides an interesting collection of less finished work, showing the earlier attempts of the inventors and the progress of the invention. It is claimed for these that they exceed in purity of colour and in durability any chromo-lithograph, but it may fairly be said that they are quite as good, while they can be produced in a tenth of the time and presumably at less cost. The process employed is similar to the one above alluded to, in that the impression is taken from the actual surface of the colour; but, instead of the cakes of colour being cut out and then pieced together, the required arrangement is produced as follows:—The colour is in a liquid state, but is of such a character that it rapidly solidifies. A little of it is poured on a flat slab into a sort of little cell or compartment formed by slips of metal standing edgewise on the slab. As soon as this has become solid the slips are removed, and the little mass of colour pared away to the outline required. The next colour is similarly applied, then the next to that, and so on, until the picture is thus built up piece by piece. The paring away is done by a vertical knife fixed in a frame, so that it can be moved sideways in any direction, but all its cuts are perfectly vertical. From the compound block thus produced, the picture is printed in a press like that used for lithography. To finish the picture it is necessary to print in the outlines by a second printing, and in some cases a third overprint is given to obtain different shades; but all the colours are given in the first impression alone. The first feeling on reading the above description will naturally be surprise that so rough-and-ready a process can produce anything like artistic effects. To this the answer is that there are the pictures as witness, and that there is no known process by which some of them—notably certain test pictures of Indian scenes, remarkable chiefly for the number and variety of the colours employed in them—could have been printed. The chief difficulty has been in obtaining colours of a uniform consistency, so that they will all wear down evenly; but it is said that this has been overcome.—See *Society of Arts Journal*.

PRIVET BERRIES. Used in adulterating wines. See WINES.

PROPYLENE. C^3H^6. This hydrocarbon is formed in various ways. See COAL GAS. Consult WATTS'S *Dictionary of Chemistry* (2nd Supplement).

PSILOMELANE-LITHIA. Mineralogists have distinguished some manganese ores as baryta-psilomelane and potash-psilomelane, and of late years lithia has also been recognised.

M. H. LASPEYRES has analysed a specimen of this mineral found in the crystalline slate of the neighbourhood of Salm Château, in Belgium. It formed a plate 2 centimètres thick, conchoidal in fracture, perfectly homogeneous and opaque. The freshly broken surface was dull blue black. It gave on analysis—

Oxide of manganese	73·728
Silica	0·120
Oxide of copper	0·078
" cobalt	0·116
Lime	0·255
Magnesia	0·076
Alumina	2·452
Oxide of iron	0·148
Potash	3·289
Soda	0·813
Lithia	0·468
Oxygen	14·658
Water	3·764

M. H. LASPEYRES gives the analyses of 22 varieties of psilomelane. Still it does not appear that the small quantity of lithia found is sufficient to warrant the formation of a separate species.—*Jour. Prac. Chem.*, (2) xiii.

PUDDLING. See IRON AND STEEL pp. 451, 457. Since the article referred to has been in type, the following patent invention by Mr. G. H. SELLERS, of Wilmington, Delaware, for revolving puddlers, has been brought under notice.

The inventor has noticed that during the boiling stage of the puddling operation

the charge swells, and, overflowing the mouth of the puddling vessel, backs up on the bottom of the flue, and across the joint between the flue and the vessel. As the iron comes to nature the charge subsides, and the liquid mass gradually retires within the vessel, the joint being close enough to retain the expanding and subsiding overflow within the flue and the vessel, yet not so close but that some portion of it will penetrate the joint, so that with the broad joint, and the lowered temperature induced thereby, whether with or without the water circulation, the cinder which penetrates the joint is chilled therein, clings to the surfaces thereof, and accumulates upon itself as the operation continues, the accretion forming irregularly around the revolving surface, and almost entirely upon the lower side of the stationary surface, the whole of it attaining a degree of toughness which renders its removal extremely difficult after the operation is completed. In its condition during the puddling operation this viscous accumulation produces great friction, and causes a gradual enlargement of the joint upon one side. To resist this tendency, great pressure has been resorted to, and this pressure, while measurably retarding the enlargement, greatly increases the friction and consequent loss of power.

The invention of Mr. G. H. Sellers consists in maintaining the joint surfaces between the revolving furnace and its fixed flues at a temperature so high as will not only prevent the overflowing cinder which penetrates the joint from becoming cold and tough enough to build up on the surfaces of the joint, but, by avoiding the chilling of this cinder, to keep it in so friable a condition that it will be ground up between the surfaces of the joint, and instead of building up irregularly upon the joint it will be discharged therefrom in small grains or powder; and this is accomplished (without any change in the character, supply, or application of the flame or fuel), by dispensing with any cooling circulation about the joint, and by making the surfaces of the joint-rings on the open ends of the vessel, and on their corresponding flues, narrower than those heretofore employed.

In practice the joint surfaces should be maintained at or near a red heat, and that they may withstand such temperature without the aid of a water circulation, and resist the wear from the cinder to which they are exposed during the operation of the machine, it is preferable to make the rings of wrought iron or steel.

In the use of a puddling vessel with gaseous fuel, a joint, the surface of which has a breadth of 1½ in., meets all the requirements of the improved operation. Of course, a greater or less breadth may be found compatible with the maintenance of the proper conditions of the joint and the cinder, as above set forth; but all such variations will be comprised within the knowledge of the constructor or operator.

The base-plate encircles the mouth of the puddling vessel, and a similar one encloses the flues, through which flues the flame or fuel enters the vessel, and the products of combustion are discharged. To these base-plates are secured joint-rings, preferably by rivets, in such manner that they can be conveniently removed. The rings are flanged to afford a means of securing them to the base-plates without exposing the fastenings to wear during the operation of the machine.

PUDROLITHE OR ROCK POWDER. This explosive compound is of an analogous character to the Tonite. Experiments have been tried in North Wales, which were, on the whole, satisfactory. See Explosive Compounds.

PULSOMETER, THE. Savery's engine was patented in 1698, and we learn that some trials were made with it in some of the Cornish mines. Wheal Vor, near Helston, is named as one of the mines employing Savery's engine for pumping, and Creegbrawse, in Gwennap, is said to have been another. We have made most careful inquiries, but with no very satisfactory result. It appears probable that the engine was used at Wheal Vor—beyond that little can be learnt.

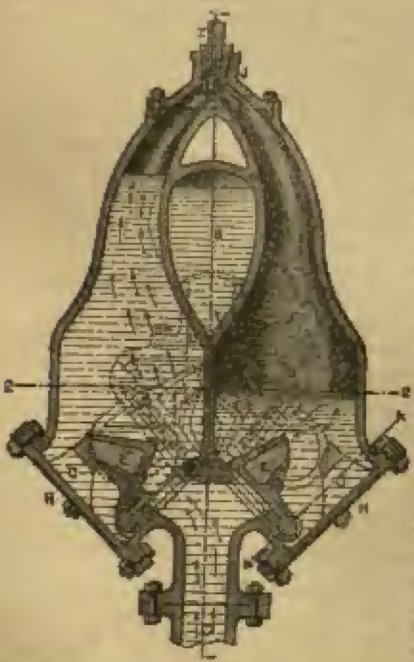
This early steam-engine will be familiar to engineers. In Savery's engine the cylinders were large in diameter, and alternately cooled by the outside application or by internal jets of cold water. The condensation thus effected produced a vacuum in the cylinder under operation, which thereby became filled with water from the mine by atmospheric pressure. The steam was then readmitted upon the surface of the water, which was thus ejected into the rising main pipe and discharged. These intermittent admissions of steam and of internal or external condensing water had to be effected by hand, as there was no mechanical motion from which to obtain the opening and closing of the valves.

The pulsometer is the name given to a modification of the Savery engine, in which the objection named has been, to a great extent, skilfully overcome. The peculiar flask-like shape of the working cylinders enables the steam to drive out the water without agitation and with the minimum of condensing surface until momentum has been set up. At the moment when the water has descended as low as the orifice which leads to the discharge, the steam passes through with the water, and ascending, instantaneously condenses. A vacuum is thus so rapidly formed in the chamber

lately filled with steam, that the steam passes through the admission valve with excessive force. This admission valve is a small ball which continually oscillates upon a sharp edge between two alternative seats. When fully resting in one it is never raised more than from $\frac{1}{32}$ to $\frac{1}{8}$ above its alternative seat, and thus is easily drawn over upon the open seating by any acceleration in the passage of the steam. These changes become so rapid, and are completed so instantaneously, that in the smaller sizes the alternate opening and closing of the steam valve sounds as rapid as a pulse; hence the name applied to the pump.

Messrs. HODGKIN, NEWHAUS, and COMPANY, of Battersea, are the English agents for this American steam-pump. It was illustrated and described some years since in *The Engineer*, but the English makers have introduced several improvements, principally in matters of design and workmanship, which render it, in their hands, a much superior machine. The pulsometer was never exhibited before in England, and as the apparatus is curious and, though simple, not easily understood, it is described at some length, the description being condensed from that prepared by the patentees. The pulsometer consists mainly of a single casting called the body, which is composed of two chambers, A A, *fig.* 2459, joined side by side, with tapering necks bent towards each other, and surmounted by another casting called the neck, J, accurately fitted and bolted to it, in which the two passages terminate in a common steam chamber, wherein the ball-valve is fitted, so as to be capable of oscillation between seats formed in the junction. Downwards the chambers are connected with the induction passage, C, wherein the inlet valves, B B, are arranged. A discharge chamber, common to both chambers, and leading to the discharge pipe, D, is also provided, and this also contains one or two valves, F F, according to the purpose to be fulfilled by the pump. The air-chamber, D, is made in the same casting as the chambers, and communicates with the suction. The induction and discharge chambers are closed by covers, H H, readily removed when access to the valves is required. G G are guards which control the amount of opening of the valves, B B. Small air-cocks are screwed into the cylinders and air-chamber. The pump being filled with water, either by pouring water through the opening in the chamber, or by drawing the charge, it is ready for work. Steam being admitted through the steam-pipe, E, passes down that side of the steam neck which is left open to it by the position of the steam ball, and presses upon the small surface of water in the chamber which is exposed to it, depressing it without agitation, and, consequently, with but slight condensation, and driving it through the discharge opening and valve into the rising main. It should here be noted that the success claimed for the pulsometer is in great measure due to the arrangements for preventing the steam from being largely condensed by contact with the water or other liquid which is to be pumped during the emptying of the chamber. To this effect the peculiar form of the chambers greatly contributes.

2459



The accompanying figure shows the mechanical construction of the pulsometer. It is a vertical section of the apparatus taken through the centre of the water chamber. The body of the apparatus is divided internally into two chambers, A A, which are separated by a vertical partition cast in one with the outer part. The figure of the body is of a pear-shaped form, tapering upwards to the neck, J. The vertical partition extends laterally on each side at the upper part, where it forms the elliptical air chamber, D, which communicates with the suction. The arrangement of this part is modified, and the

partition forms a diaphragm, one side of which communicates with the delivery and the other with the suction. The fluid to be raised flows upwards by the induction passage, C, which opens out on either side into the chambers, A A. These openings have fitted to them the valves, B B. This portion of the arrangement is shown clearly in the section. A discharge chamber common to both leads to the discharge, D. This chamber is also provided with two valves, F F, according to the purpose to which the pump is applied. G and H are adjusting plates, by which the interior of the machine is reached, and I, J, and K indicate respectively the outlets of the pump.

PULVERIZER. At PENHALL's Mine, St. Agnes, Cornwall, a machine for pulverizing tin—the invention of Mr. CURTIS—has been for some time in use.

Its construction is very simple, and its efficiency is all that can be reasonably desired, both as to the motive power required and the work accomplished. The machine in this case is attached by cog wheels to the end of the stamps' axle, and is so regulated as to work ten revolutions to one of the stamps' axle, or at about an average speed of 120 revolutions per minute. The disc revolves, and has on its surface six slots and several holes sunk into its depth within ¼ inch of being through the disc; these slots are for the conveyance of the sand from the hopper in the required quantity, and also for regulating the degree of fineness to which it is desired it should be pulverised (and consequently the less the quantity discharged), so that the requisite degree of fineness may be easily obtained for any class of stuff by simply plugging up the outer portion of these slots with a piece of iron. The upper disc simply rests its weight on the lower one when at work, and is prevented from revolving by two slots working loosely over a bracket fixed to the frame. By means of two screws its weight is on all occasions lifted off the lower disc by a boy in attendance whenever the stamps stop, and is not again lowered until after the machine has been set in motion. This in practice was found a very necessary precaution to prevent the teeth of the wheels being broken. A pair of discs will last from four to six months, and the upper one is weighted as it becomes worn. When kept working at the speed of 120 revolutions per minute it will pulverise 12 tons of the hardest caple sand in this mine in twenty-four hours, sufficiently fine for the extraction of all the tin worth saving, a result which formerly required twelve stamp heads to accomplish and by no means in such a satisfactory manner. In stamping much of the tin ore is pulverised too fine, and consequently lost, and this cannot well be avoided, as the specific gravity of the ore tends to keep it under the battery longer than any of the substances associated with it; but with the pulveriser the specific gravity does not signify and consequently much less 'slime' tin produced—a very important consideration.

At Phœnix United Mines, near Liskeard, in Cornwall, Mr. WILLIAM WEST has fitted up two pulverisers which answer exceedingly well.

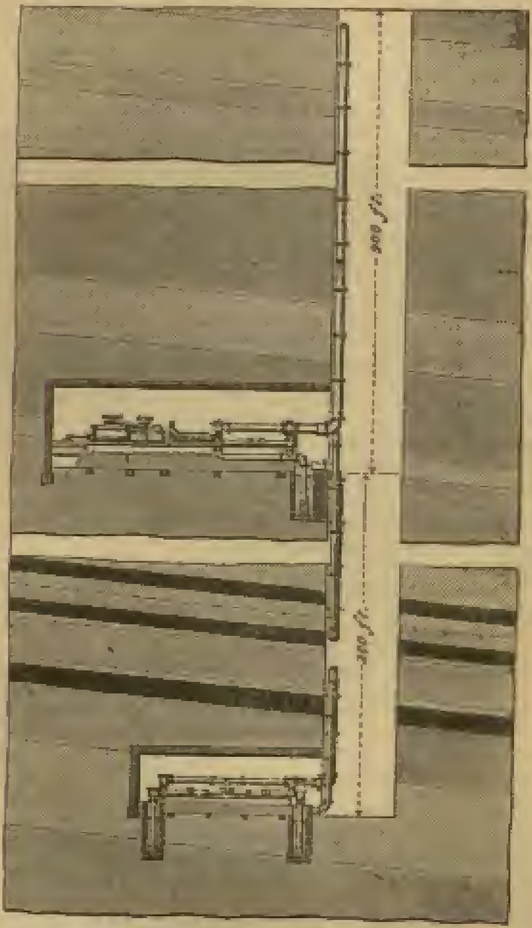
PUMPING-ENGINE FOR UNDERGROUND. Mr. DAVEY, of Leeds, has patented a compound differential pumping-engine of considerable value, as it respects economy of fuel and several other points, and especially for its adaptability to underground use. We are more especially concerned with this application. A modified form of this engine for underground work is shown (*fig.* 2460). In a paper read by Mr. DAVEY before the Northern and Midland Institute of Mining Engineers the theory of his engine is fully set forth. We have been furnished by Mr. DAVEY with the following abstract:—

As economy of fuel is the most important question connected with pumping machinery, it will be well to examine and see if the differential engine possesses the elements required to constitute it an economical engine, and in order to do this it will be necessary to determine in what steam-engine economy consists. First, let it be observed, that to estimate the efficiency of the engine in terms of pounds of fuel burnt per indicated horse-power is, like many of the practical rules used by engineers, fallacious. The only scientific, and consequently the only true, method is to estimate the efficiency in terms of pounds of steam passing through the engine per indicated horse-power developed.

The leading principle of economy is expansion, and the engine which will work with the greatest amount of expansion is *cæteris paribus* the most economical; there are, however, certain conditions necessary to expansive working. The resistance to be overcome in pumping is almost constant, and the force applied to overcome that resistance by the expansion of steam varies. It is evident that the mean of the two forces must coincide, but the extremes greatly vary. The steam pressure is too great at the commencement of the stroke, and too small at the end. A means then is required whereby the work due to expansion may be stored up whilst the piston is moving from its first position, and given out again whilst it is further moving to its second place. This function is performed in the Cornish engine by the inertia and momentum of the pitwork, beam column, and other moving matter, and in the rota-

tive engine by that of the fly-wheel. The elements of this compensating force, or vis viva, are weight and velocity, expressed by the equation $\frac{W V^2}{2 g}$. It is evident to the casual observer that such a condition of things must cause an enormous strain, above

2460



the resistance of the pump, to be put on the engine at the commencement of the stroke, when a high degree of expansion is employed, and further that the piston speed at the point of crossing of the two lines must be very great. It follows then as corollaries:—

1. That, to expand to a great extent in a single cylinder, a great strain must be put on the engine above that necessary to overcome the resistance of working the pumps.

2. That a great moving mass must be provided, and a great maximum piston speed employed, to render expansive working in a high degree practicable in a single cylinder.

In practice the first of these corollaries is illustrated in the great number of accidents which have taken place with the Cornish engines, working with a high degree of expansion, and, in consequence, expansion has of late years been very much reduced, causing a large falling off in duty.

The second is illustrated by the fact that it has not been found practicable to work Cornish engines expansively with a moderate piston speed, such as is necessary in lifting water. The only condition under which the Cornish engine has proved itself an economical machine is that of actuating plunger lifts, where a great mass of matter has been lifted at a great speed, and caused to fall slowly in lifting the water in the pumps.

These are two of the most serious difficulties surmounted by the compound differential engine. An inspection of the diagrams obtained from one of these engines showed that the variation in force between the commencement and end of the stroke is as $2\frac{1}{4}$ to 1; whereas, in the single cylinder, with the same degree of expansion, it would be 6·3 to 1; that is to say, the variation in the two pressures is nearly three times as great, in the case of the Cornish engine, as that in the compound differential.

As this variation has to be compensated by weight and velocity, it is evident that, with the smaller variation, less weight and less speed are required.

Tests already made with these engines prove conclusively that the highest economy is practicable without the heavy strains and high maximum speeds necessary to economy in the Cornish engine; and, as it is double acting, it has a far greater power for a given size of cylinder.

Mr. DAVEY communicated to *Engineering* a paper explaining yet more fully the methods by which the difficulties attending the Cornish system for pumping-engines have been to a greater or less degree overcome. That gentleman has furnished us with a copy of the original paper.

'The first and most obvious of these is that of making the pitwork very much heavier than the column of water which it has to lift in its fall, balancing of course the greater portion of this excess by suitable counterweights. So far as the question at present before us is concerned, this may be looked at as equivalent to increasing the weight to be raised, from W to (say) W^1, but, at the same time, adding another cylinder in which a *constant* pressure $= W^1 - W$ is exerted. Thus p' remains the same, but it is no longer equal to w, which must be increased to w^1, the whole weight of the pitwork $\div$ the cylinder area. In finding the velocity, therefore, we must no longer take $w = p' = a\ h$, but must take this new value w^1, the rest of the computation remaining the same. For the sake of getting sufficient stiffness in the pump rods, some excess of weight may be necessary, otherwise, however, it is obviously a most unsatisfactory mode of attaining the desired end. Its drawbacks are so great that in the North, indeed generally out of Cornwall, it is the custom to use bucket-pumps instead of plungers, so that the pump rods may be lightened by being used in tension instead of in compression. The lifting is done on the steam stroke instead of on the equilibrium stroke, and the velocity of the piston is limited by the velocity at which the water may be moved through the pipes, instead of that at which the pitwork may be allowed to rise. In the Cornish engines now reported, the average speed of the pumps is only 63 ft. per minute; the in-door stroke is made in little more than half the time of the out-door, so that even if the pauses were extremely long, still the average speed of the water, while being lifted, can hardly exceed 1 ft. per second. No doubt this may be somewhat increased in the winter, more strokes per minute being made (although there is no sensible difference in this respect between the June and September reports of this year), and no doubt also it is very greatly exceeded in other parts of the country. Still, allowing for pauses, 3 ft. or 4 ft. per second would be a high average actual speed for a water lift, and 5 ft. to 7 ft. a high maximum speed, and it will be evident that with such a velocity and with ordinary water loads, but little expansion can be employed; as a matter of fact we believe that the Cornish engines used in the North scarcely expand their steam at all.

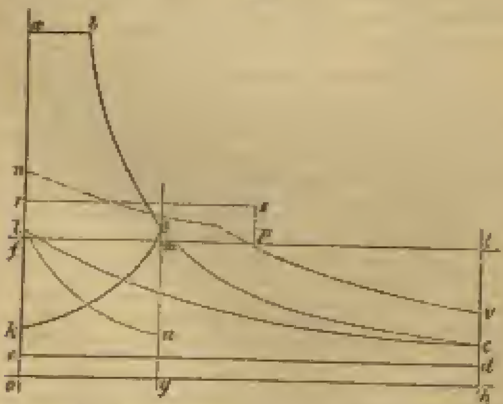
'Nor can it be considered that such a satisfactory solution is furnished by rotary engines, where the additional weight required to equalise the velocity is put into the shape of a flywheel. It is certainly better in the abstract that a flywheel rim, which can be allowed to move continuously at a much greater velocity than the pitwork, should be employed to absorb energy during the acceleration than that weight should be added to the pitwork for that purpose, but there are two great objections to it. First, the connecting rod, shaft, and flywheel add greatly to the expense and complication of the engine, and secondly, the discontinuous motion of the Cornish and other non-rotative engines seems certainly to be more suitable for pumping, especially in the case of high lifts, than the continuous motion of engines with a flywheel. Unless these are geared, too, their velocity must be limited by the maximum velocity at which it is thought desirable to lift the column of water. Where the pumping work is light, and where, at the same time, a rotary motion is required for driving other machinery, the use of fast-running geared engines may be advantageous, but not, we think, where really heavy pumping has to be done.

'One of the solutions most early suggested, and one upon which much labour has

been expended, is the one to which it seems certain that we must look for the true way out of the difficulty, namely, the employment of two cylinders instead of one. HORNBLOWER'S double-cylinder engine was in the field almost as early as WATT'S engine, and it may be remembered that for many years WOLF'S improvements on HORNBLOWER'S engine competed with TREVITHICK'S improvements on WATT'S, until at last the superior qualities of TREVITHICK'S machines became so clearly evident that for a time they superseded all others. The double-cylinder engine was, however, advocated for entirely different reasons to those which we are now discussing, for reasons indeed which were not always very well understood or explained even by its strongest upholders. The application of the compound principle to single-acting engines presents many difficulties, and most of the forms in which it was applied—looked back upon in the light of our own greater experience in the matter—seem to have been very defective. The engines were generally arranged so that during one stroke[2] the high-pressure steam acted on one side of its piston, the other side, and that of the low-pressure piston, being in communication with the condenser, while in the next stroke there was free communication between the two pistons. We do not propose here to enter into the thermodynamic disadvantages possessed by such an arrangement as this. It would only partially serve the purpose we have now in view, and the inconveniences attendant on its application to any engine working single-acting pumps are sufficiently obvious. Probably the only compound engine suitable for such a case would be one with a large receiver between the cylinders, into which during the one stroke the high-pressure cylinder should exhaust, and from which during the first part of the next stroke, the low-pressure cylinder should take its steam. In principle, such an engine would be efficient enough, if the cuts-off in the two cylinders were carefully fixed with reference to the large receiver capacity, but in all probability the actual loss of heat due to the use of such a receiver would be so great as to neutralise, in a large measure, its advantages. We are not aware that such an engine has ever been made.

[1]This difficulty would entirely disappear if the engine could be so arranged as to lift water both on the in-door and on the out-door strokes. One end of each cylinder would thus always be doing work, and each end of the high-pressure cylinder would exhaust direct into the other end of the low-pressure cylinder, no receiver being necessary or desirable. This arrangement of the pumping can be carried out without more difficulties than naturally accompany the introduction of anything which varies from established custom. Let us suppose these obstacles to be overcome, and examine how far really the compound engine will here serve our purpose. We shall then glance at the necessary alterations in the pumps and pitwork, and finally illustrate the whole matter by drawings of such a compound engine, which have been kindly placed at our disposal by its makers, and which contain some features of special interest in other directions than those in which we have been working.

2461



[1] In *fig.* 2461, let *a b c d e* be the diagram with which we started; $p^1 = 60$ lb. per square inch, $p^m = 23{\cdot}5$ lb., $p^a = 20$ lb., $p^b = 3{\cdot}5$ lb., and $r = 7{\cdot}75$. Considered as belonging to a single cylinder engine, the work of acceleration per stroke was equal

[2] Either in-door or out-door.

to $\frac{1}{3\cdot24}$ of the total work, and the maximum velocity of the piston was 15 ft. per second. Our problem is to examine what these quantities would become if the same amount of steam, doing the same amount of work, were used in two suitably proportioned cylinders instead of one. Let us suppose our low-pressure cylinder to be the same size as the original cylinder and the high-pressure cylinder 0·3 as large. Let $o\,g=0{\cdot}3\,o\,h$, represent the capacity of the high-pressure cylinder on the same scale as $o\,h$ does that of the low pressure, then $a\,b$ may stand as before for the quantity of steam used at p', $\frac{o\,g}{a\,b}$ will be the ratio of expansion in the high-pressure cylinder, and $b\,k$, a part of the original expansion curve, will be the curve for the high-pressure expansion. Most of our readers must be sufficiently familiar with this way of treating compound engine cards to render further explanation of it unnecessary. To simplify matters we shall neglect both clearance and intermediate passage between cylinders—no cut-off will then be wanted in the low-pressure stroke, and there will be no compression used. At i the high-pressure cylinder begins to exhaust, and remains throughout the return stroke in full communication with the low-pressure cylinder; points in the two simultaneous curves $i\,k$ and $l\,e$ are therefore easily found; e, the final pressure in the low-pressure cylinder, must coincide, as shown, with the final pressure in the original expansion: $a\,b\,i\,k$ is the high-pressure card, $l\,e\,d\,e$ the low-pressure card, and together they are exactly equal in area to $a\,b\,c\,d\,e$, the original card for a single cylinder, so that so far the conditions of the problem have been observed. But although $a\,b\,i\,k$ represents the work done in the high-pressure cylinder, its ordinates do not give us the actual effort exerted at any instant on the piston. To find this we must obviously reverse the curve $i\,k$, placing it in the position $l\,u$, for $g\,i=o\,l$ is the pressure upon one side of the high-pressure piston when $o\,a$ is the pressure on the other; $a\,k=g\,u$ is the pressure on the one side when there is $l\,g$ upon the other, and so for all intermediate points. By taking a sufficient number of ordinates of this high-pressure card, $a\,b\,i\,u\,l$, reducing each in the ratio $\frac{o\,g}{o\,h}$ (this can, of course, be done geometrically with great ease), and adding them to the corresponding ordinates of the low-pressure card, we get the card $a\,p\,r\,d\,e$, the ordinates of which give us for each instant the equivalent of the total forward pressure in both cylinders in pounds per square inch of the low-pressure piston. The area $a\,p\,r\,d\,e$ of course $=$ $a\,b\,i\,k+l\,e\,d\,e=a\,b\,c\,d\,e=f\,t\,d\,e$. The work of acceleration is now $=a\,p\,f$, p being the point of maximum velocity; reduced to a rectangle this gives us $r\,s\,p\,f$, and we find the corresponding maximum velocity to be 10 ft. per second instead of 15 ft. We thus find that a ratio of expansion which would give a maximum velocity—in the case supposed—of 15 ft. per second in a Cornish engine, would give only two-thirds as much in the compound, or but little more than we found, in the former case, to correspond to a twofold expansion. By further calculation we find that a *sixfold* expansion could be used in this case without exceeding the maximum speed of 9 ft. per second. Here we have at once, for any given *maximum* velocity, *three times* as great expansion possible in the compound engine as in the single. But the real advantage of the former is even greater than this. In a single engine the acceleration is very sudden, and the mean velocity is a very large fraction of the maximum; here the acceleration is more nearly uniform and the mean velocity relatively less. The effect of the intermediate passage between the cylinders (which for simplicity's sake we have not here taken into account) is to make it less still, affecting the maximum velocity but little; and the influences in the same direction of the various causes which make the actual indicator card differ from the theoretical are in general proportionately greater in the compound than in the single engine, so that, taking all these things into account, we may say that for any given mean velocity of piston a compound pumping engine may expand about four times as much as a single engine having the same indicated horse-power. Such a text hardly needs a sermon.'

Mr. Davey, in a private communication, remarks that 'the underground engines (*fig.* 2460) do not work quite so economically as those placed on the surface, for the reason that there is extra condensation in the steam-pipes, and it is not practicable to employ so large a measure of expansion. In the surface compound engines, the duty has been found to be from 20 to 22 lb. of steam per indicated horse-power per hour, and the patentee expects to exceed that duty in a new arrangement of the cylinders, when he has reduced the losses (from passages) to a minimum.'

To compare this system with others, one or two examples must be given. In the *Engineer* is illustrated a pumping engine built in America from designs of Mr. West; that engine weighs 650 tons. Mr. Davey just designed an engine of the *same power* (for a mine in Nevada) weighing only 120 tons, which engine will give a much higher duty.

These engines are constructed by the firm of HATHORN, DAVIS, CAMPBELL, and DAVEY, Sun Foundry, Leeds.

PUMPING ENGINE, HYDRAULIC. In connection with the underground pumping engine which we have illustrated, *fig.* 2160, it appears desirable to give some description of the applications made by the patentee of hydraulic engines in mines.

There are many situations in which a small quantity of water supplied under considerable pressure can be profitably employed to pump a greater quantity of water against a less pressure. In dip workings in collieries, for instance, engines thus worked can be advantageously used to raise water to the main pumping engines, the motive water in this case being supplied from the rising main of the main engine. In hilly mining districts, too, water drawn from a high level may be conducted by pipes into the mines, and then used to raise a greater quantity of water to the surface, thus avoiding the necessity for steam power. For use in such situations as we have alluded to, engines are now being constructed on the plans of Mr. HENRY DAVEY. In our engravings, *figs.* 2461 and 2462, are respectively a general arrangement and plan of one of these hydraulic engines, as employed for both pumping and hauling.

The engine has been designed to obviate the difficulties of wear and tear experienced with engines having pistons and slide valves, and gearing for working the valves. Pistons and slide valves wear very rapidly with dirty water, but plungers are practically unaffected. It will be seen that in the engine illustrated there are no pistons, but the power is applied and the work done entirely with plungers. The power plungers are stationary, and are made to serve as pipes to convey the water from the valve box (to which they are fixed) to the inside of the pump plungers; these latter forming the power cylinders, and being connected to each other by side rods passing outside the valve box. In this way the forcing stroke of one pump plunger causes the suction stroke of the other, and *vice versâ*.

The most novel part of the engine is the valve box. For hydraulic power no valves answer better than the single mitre valve; for if these valves do get leaky because of sand and grit, they are easily replaced by duplicates, or ground tight. The difficulty with single mitre valves of the ordinary type is, however, that of working them, when made of sufficient size to produce but little throttling. This difficulty is entirely obviated in the engine under notice, for the valves, instead of being actuated by means of metallic connections, are worked under water-pressure by means of a small subsidiary valve acted on by tappets from the engine at the ends of the stroke. On this construction the valves may be made of any size, and a full and free water-way given, so as to realise the greatest possible useful effect. By regulating the passages between the subsidiary and main valves, the latter are made to rise and fall at any required speed, so that the 'beat' may be entirely taken off, and the wear and tear of the valves reduced to a minimum.

Altogether we think that the plan of employing hydraulic pumping engines in the manner to which we have referred has not yet received the attention it merits. Metallic mines are very frequently situated in hilly districts, and in many such cases, as we have said, the use of steam power for pumping might be altogether avoided by the employment of hydraulic pumping machinery, the latter possessing amongst other features the advantage that in the event of the mine flooding it may continue to be worked under water.

Mr. HENRY DAVEY hands us the following remarks contributed by him to *Engineering*:—

'The use of the hydraulic pumping engines for draining dip workings is a practice which appears likely to be much extended on account of the conveniences attendant upon it, and for this reason we believe that many of our readers will regard with interest the engine and arrangement shown, *figs.* 2462, 2463. The engine employed at the Seaton Delaval Colliery is proportioned for raising 100 gallons per minute 60 feet high, the water for working it being supplied under an effective pressure of 165 lbs. per square inch. For "dip" workings a different class of engine is required, engines for such workings having to be small and compact, so that they can be readily fixed upon a plank and carried forward as the working proceeds. For such purposes a number of engines with slide valves of lignum-vitæ have been made, but it has been found that when the water was muddy and the pressure heavy, such valves wore very fast, and hence Mr. DAVEY was led to design a new arrangement of valves, which are employed on the underground engines, which arrangement has proved most satisfactory in its action.

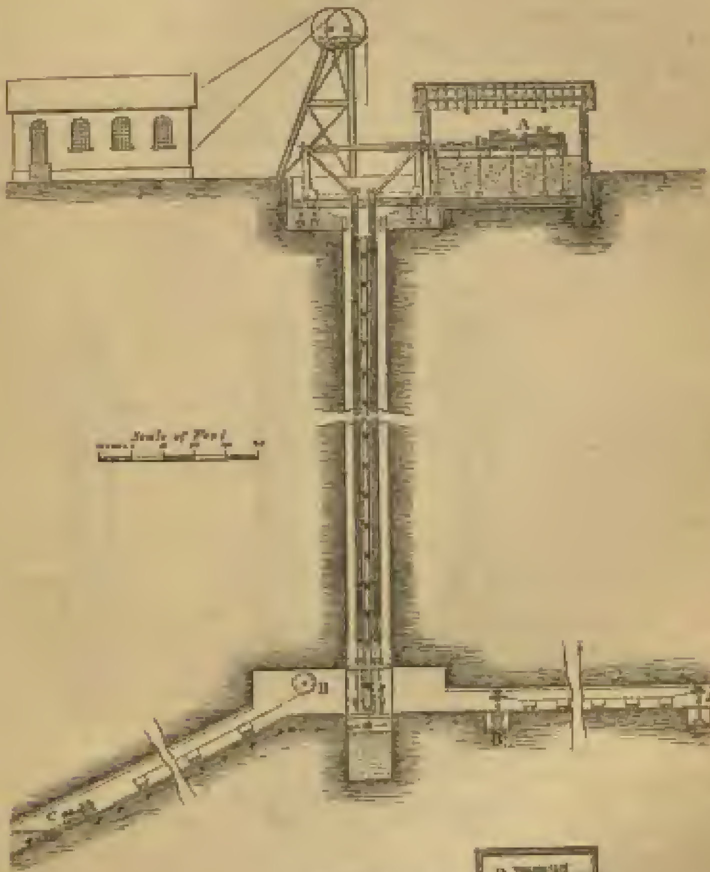
'Both the exhaust and admission valves are single mitre valves, and they are capable of working under the heaviest pressures. The exhaust from the engine is discharged into the delivery pipe of the pump, and as this takes place only during the backward stroke, the area of the plunger is, in designing these engines, first

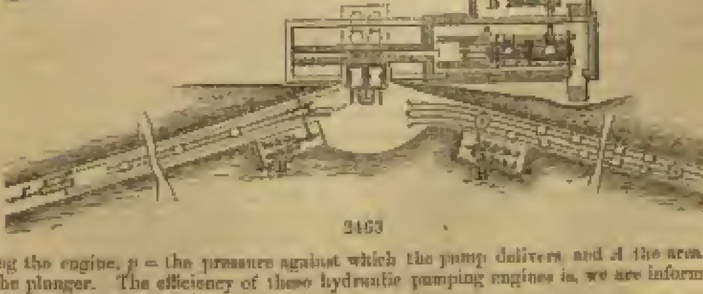
determined, and the area of the annular space is then obtained by the following formula:—

$$x = \frac{AP + Ap}{P - p}.$$

In which x = the area of the annular space, P = the effective pressure of water work-

2462





2463

ing the engine, p = the pressure against which the pump delivers and A the area of the plunger. 'The efficiency of these hydraulic pumping engines is, we are informed, from 70 to 80 per cent.'

The same hydraulic engine is employed for underground hauling. The engine, A, puts in motion the drum D, *fig.* 2463, which is brought into connection with [illegible] at the

top of the dip-workings. Wire rope connected with the trucks, c, work the carriages up and down the tramways in either gallery. The facilities afforded by this arrangement are very great, and it will probably be largely adopted in deep and extensive coal workings.

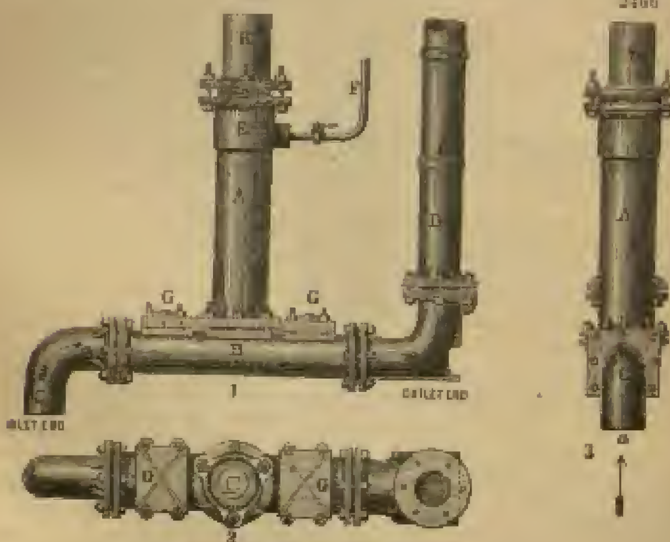
PUMP, SAND. When dressing floors are situated on a common level, without a gravitating fall, it is frequently necessary to lift sand and slimes from the end of one enriching apparatus to the head of another, so as to continue and complete the dressing process.

Various forms of lifting apparatus are employed for this purpose, such as the scoop wheel, Archimedean screw, and chain elevator.

At the Moonta Copper Mines, South Australia, Mr. HANCOCK, the Director of the Works, employs an ordinary plunger, having a water pressure pipe fitted to the plunger case, for lifting the sand and water flowing from the reducing and other machinery to the jiggers. *Fig.* 2464 is a front, *fig.* 2465 an end elevation, and *fig.* 2466 a plan of the plunger apparatus, which, with the following description of its parts, will be rendered clear:—

A, plunger case; B, clack box fitted with ordinary inlet and outlet clack, G G; C, inlet pipe; D, outlet pipe, or column; E, plunger gland box; F, pressure pipe introduced into the gland box, immediately below the packing, so as to keep the sand below this line; H, plunger. The arrows in *figs.* 2464 and 2465 indicate the course of the sand and water.

2464 2466



2465

The pressure pipe, about an inch in diameter, provided with a regulating cock, is placed in connection with a small water cistern set a few feet higher than the top of the delivery column, D. In working this pump, the pressure of water obtained by means of the cistern and pressure pipe, F, being in excess of the working load, or resistance on the end of the plunger, prevents any sand from rising above the zone of the water delivery. The plunger packing is thereby kept freer from grit, and consequently rendered very durable.

PURPLE OF CASSIUS. See CASSIUS, PURPLE OF (vol. i. p. 747). M. H. DEBRAY, recently read before the *Académie des Sciences* a paper on this interesting chemical compound, of which the following is a translation from the *Comptes Rendus*:—

'When a solution containing simultaneously protochloride and bichloride of tin is poured into a very dilute solution of chloride of gold, the result is the formation of a brown-coloured fluid, which is turbid when seen by reflected, and purple when seen by transmitted light; while after a time a coloured precipitate is deposited in the liquid, which is the so-called purple of Cassius, and is—as is well known—the basis

of all gold pigments employed in glass and porcelain staining for the purpose of producing rose, red, and violet colours.

'The purple of Cassius may also be obtained under other conditions, and its composition varies with its mode of preparation, but is always such that it (the purple) may be represented as consisting of hydrated binoxide of tin and metallic gold in a very finely divided state. The colour of this substance is the deeper the more gold it contains, but does not differ from the hues which the precipitation of gold alone can produce, so that MACQUER, who first made this observation, viewed the purple of Cassius as a mixture of gold and hydrated binoxide of tin. PROUST having observed that the purple dissolves in ammonia while still wet, and that on being triturated with mercury it yields no gold, the mixture hypothesis was generally abandoned, and the purple was considered to be a chemical combination. The only rational mode of viewing the composition of this combination was to consider it to be a saline oxide, that is to say, a stannate of protoxide of tin and suboxide of gold, the latter containing a sufficient quantity of oxygen to convert the protoxide of tin into binoxide. This saline oxide might, moreover, be mixed with a variable proportion of stannic hydrate (*hydrate stannique*).

'Since PROUST's days, there have been many discussions, and more researches, on the constitution of the purple of Cassius. It would be impossible to give a *résumé* of these labours here; suffice it to say that no decisive arguments or any new view has been published in favour of either of the two hypotheses just alluded to, and which, in my opinion, are quite erroneous. I consider the purple of Cassius to be a lake of stannic (or metastannic) acid coloured by very minutely divided gold. The colouring matter of this lake has become insolvent in its usual solvent, mercury, just as the fast colours of the dyer resist the action of water in consequence of their union with the fibres of the woven fabrics, or with the mordants. The following results of experiments, and explanation of facts discovered by me, will, I hope, completely justify this mode of viewing the purple of Cassius. I boil together a mixture of solutions of bichloride of tin and acetate of soda; the result is that binoxide of tin is precipitated. I next pour into the hot liquid a small quantity of chloride of gold, and then some oxalate of potassa; the result of which is that the gold is immediately reduced, and while only a small quantity of the metal is precipitated on the glass, the bulk of it is precipitated upon the oxide of tin, which thereby assumes the ordinary colour of the purple of Cassius. A perfectly similar colour can be produced with alumina by precipitating gold in a fluid which contains alumina in a state of suspension. For this purpose, I add to a solution of chloride of gold, saturated with acetate of soda, gelatinous alumina, and to the hot mixture I add gradually oxalate of potassa, whereby the gold is reduced. These two lakes having been kept suspended in water and shaken up in a closed strong glass vessel for several hours with mercury, have not lost their colour.

'The ordinary method of preparing the purple of Cassius does not evidently differ from that just alluded to, except that the oxide and the colouring matter are precipitated together, by which means the beauty of the colour is undoubtedly increased, as well as its fastness towards mercury. It now remains to be explained how it is that this lake is soluble in ammonia. We know that oxide of tin is soluble in ammonia when precipitated at the ordinary temperature, so long as the oxide continues wet, and that it ceases to be soluble in ammonia under various conditions, as, for instance, an elevation of temperature, and more particularly drying.

'The purple of Cassius loses its solubility in ammonia under precisely the same conditions, and hence it ought to be observed that the solution of purple of Cassius in ammonia (that solution being always turbid when viewed by reflected light) deposits slowly metallic gold, while the oxide of tin remains almost entirely in solution. This well-known fact is quite natural if the purple is a lake, but it is very difficult to explain if the gold is in the state of oxide, because the action of ammonia on the metallic oxides of the precious metals gives rise to the production of more or less complex products, but never sets the metal free.

'MERCADIEU has observed that in the assay of the precious metals, when silver, which contains a small quantity of tin and of gold, is dissolved in nitric acid, a substance is obtained very analogous to the purple of Cassius; and since gold is not oxidised by nitric acid, he inferred that the purple of Cassius contained the gold in the metallic state. GAY-LUSSAC having resumed these researches came to the same conclusion, but since this purple of Cassius so formed was not soluble in ammonia, it became necessary to demonstrate the identity, or at least the isomerism, of the two purples, GAY-LUSSAC feeling inclined to admit isomerism between the two substances. It can be proved that no other difference exists between the two purples except that due to difference of conditions under which the binoxide of tin is formed. The oxide of tin obtained by the oxidation of that metal by the aid of heat is insoluble in

ammonia, and the same holds good for the lake which it forms with gold. But if the ternary alloy of silver, gold, and tin is acted upon at a gentle heat, a purple is obtained which is soluble in ammonia, and I have found, by direct experiment, that the oxide of tin obtained under these conditions is soluble in that reagent.'—Translated in the *Chemical News.*

PURPURIN. According to M. F. DE LALANDE'S French patent, purpurin may be obtained as follows:—100 parts alizarin and 100 of dry arsenic acid are heated with 1,000 parts of sulphuric acid to 150°, until a sample taken out gives a deep red colour with soda. He then dilutes with 30 volumes of water, boils, and filters. The residue is used for dyeing. Instead of arsenic acid may be used antimonic acid, protoxide of manganese, or stannic acid.

PYRITES, AURIFEROUS. The following description of the processes adopted in the treatment of the auriferous pyrites of Victoria is taken from the report of R. BROUGH SMYTH, Secretary for Mines, and the Chief Inspector for the Mines of Victoria, a report which may be distinguished for the completeness of its details, and the clearness of the deductions drawn from the reports which have been furnished to him by the several Mine Inspectors. Mr. BROUGH SMYTH having issued circulars of inquiry, obtains the following information, especially from Mr. COSMO NEWBERY.

The remarks made by Mr. NEWBERY on the modes of treatment will be found of considerable advantage, if carefully studied, by those who, either at home or abroad, have the charge of either the auriferous, argentiferous, or cupriferous pyrites.

Memorandum relative to the Treatment of the Auriferous Pyrites Sands obtained from the Tailings of the Quartz-crushing Machines, with a View to the more Complete Extraction of the Gold and the Saving of the other Components, by Mr. COSMO NEWBERY.

'Examinations of the "pyrites" or "mundic" in the quartz lodes show that the sand may consist of the following distinct minerals:—

'1, iron pyrites; 2, arsenical pyrites (mispickel); 3, magnetic pyrites; 4, copper pyrites; 5, stibnite (sulphide of antimony); 6, galena (sulphide of lead); and 7, zinc blende. There are some rarer compounds, such as Bournonite, Boulangerite, Jamiesonite, tetrahedrite, copper glance, indigo copper, and bismuthinite; but as these have only been noticed as occurring in very small quantities, they are not likely to interfere with any process that may be adopted. At Costerfield, Ringwood, Whroo, Murchison, and Sunbury, stibnite is the most abundant. At Bourke's Flat and St. Arnaud, the "mundic" is found as masses of intimately mixed iron pyrites, galena, and zinc blende. At Sandhurst many of the veins contain little iron pyrites and large masses of arsenical pyrites. At Mount Buller the quartz lodes contain large blocks, weighing many hundred pounds, of nearly pure pyrrhotine (magnetic pyrites), and in some of the Gippsland mines nearly all the varieties have been found intimately mixed.

'In the great majority of instances any mechanical separation of these minerals is impossible, and the operation of crushing the quartz, in order to obtain the free gold, reducing the brittle mundic to a very fine sand, thoroughly mixes the minerals together, so that the manufacturer will have to be prepared to cope with a material containing sulphur, arsenic, antimony, lead, copper, and zinc, with more or less gold and silver.

'Analyses previously reported have shown that nickel, cobalt, cadmium, bismuth, and manganese are also found in some of these minerals. The nickel and cobalt may possibly be extracted economically from some of the antimonial ores with which they are associated.

'From these mixed pyritous sands only a very impure sulphuric acid can be made; an economic process for the complete removal of arsenic and antimony from sulphuric acid is still wanting, and I doubt whether the acid made from our pyrites would be able to compete with that made from native sulphur for general manufacturing and chemical purposes. It would, however, be easily prepared of sufficiently good quality for metallurgical purposes and some manufactures, so that, should works be established, there would be no difficulty in disposing of the acid made.

'The first point to be considered by the maker will be the variety of furnace to be used for roasting the ore. On account of the fine state of division of the ore, the furnaces used in English works will not be found suitable. The inclined reverberatory furnace now used on the gold fields will have to be superseded by one requiring less constant attention in charging and stirring, and one that will not admit such a great excess of air—as this large volume of atmospheric air passing into the acid chambers will cause a great loss of acid, possibly some modification of OXLAND'S, GERSTENHOFER'S, or STEDTAFELDT'S furnaces may be found suitable.

'After leaving the furnace, the gaseous products (sulphurous and arsenious acids) must pass through dry condensing chambers or flues, in order to remove the greater

part of the arsenic. The commercial demand for this substance in Australia is very small; but it must be removed from the sulphuric acid as completely as possible; and it will be advantageous, on sanitary grounds, to prevent its finding its way into the creeks and rivers of the country, as it does at present.

'When all the economically available sulphur has been removed from the ore, it may be then treated by Gibb's method—that is, roasting with common salt, so as to render the silver and copper soluble in water, from which solution they may be recovered at very small cost. The residue, after extracting the silver and copper, will then be oxide of iron, and clean free gold in a condition to be readily amalgamated by mercury. The oxide of iron residue will be of value for many manufacturing purposes. Should any of the other metals which have been mentioned be present in quantity, only slight modifications or extensions of the process will be necessary.

'The gain in adopting some such plan as that described by T. Gibb, Esq., F.C.S., in his address to the Tyne Chemical Society, for the treatment of the roasted pyritous residues obtained from the sulphuric acid works, would be a much greater return of gold from the pyrites—fully 10 or 20 per cent. more than at present—the saving of the silver, copper, &c., now wholly lost. The silver in some cases amounts to as much as from five to ten ounces per ton in the arsenical pyrites of Sandhurst, and considerably more in the ore from the St. Arnaud district. The amount of copper varies very much, but on an average the ore will be nearly as rich as that now treated in England by the wet process.'

Professor Chapman, in a letter to Mr. Newbery, says:—

'The ore, of which the gold of North Hastings is present, consists of arsenical pyrites, a mineral composed essentially of sulphur, arsenic, and iron. The gold is partly in the free state, and in this condition it can be obtained from the stamped ore by amalgamation; but the amount is insufficient to defray the cost of treatment. By far the greater quantity of the gold is intimately combined with the arsenical mineral, and is present, I have reason to believe, in the condition of an arsenide: it cannot be extracted, therefore, by any mechanical process of washing and amalgamation. If the ore be thoroughly roasted, the gold becomes set free; but this "dead-roasting," as the Germans call it, is a long and tedious operation, and one that requires special care for its successful performance. Here, where the price of labour is so high, it could scarcely be employed. If carried out too quickly, or at too high a temperature, part of the arsenic becomes permanently fixed in the ore; and if the roasting be imperfect, it had better be omitted altogether, as otherwise the free gold may become arsenicised, and none, or next to none, will be obtained by amalgamation. If, however, the stamped and properly buddled ore be mixed with a tenth of its weight of nitrate of soda, the "crude nitre" of commerce—largely used in agriculture—and the mixture be passed through an iron cylinder or gas retort, fixed at a slight inclination, and heated towards its centre to moderate redness (several of these cylinders or retorts being set, if necessary, in the same furnace stack), the sulphur and arsenic become in part rapidly eliminated, and in part absorbed chemically by the alkali of the nitrate. The ore thus treated must then be leached in water, when the soluble compounds readily dissolve out, leaving the bulk of the ore in the form of a dull red earthy residuum. This should be passed by itself a second time, and somewhat more slowly, through the heated cylinder, when practically all the gold contained in it becomes set free, and can thus be extracted by amalgamation or by chlorine. The expense of the nitrate is covered by the paint material obtainable in the form of a yellow orpiment, or Paris green, from the arsenical solution derived from the leaching of the ore; and in addition to these by-products a large amount of almost impalpable red oxide, also valuable as a paint or wash and for other purposes, is left as a final residuum in the treatment of the ore by this process. There is one point, however, which should be kept in mind with regard to the gold-bearing ore of North Hastings. The amount of gold varies considerably in different samples taken from the same vein or bed. This, as all miners know, is nothing unusual. In some samples independent assays have shown upwards of eight ounces per ton of 2,000 lb., whilst in other samples less than half an ounce may be present. It is mere folly, therefore, to operate upon a few tons, and then to drop the work if the returns do not immediately answer extravagant expectations; and, on the other hand, it is equally foolish to consider any high results obtained in this manner from a comparatively small quantity of ore, taken perhaps accidentally from a so-called "chimney-streak," as a standard of the general yield. But, taking one ton with another, it may be safely asserted that, if the above method of treatment were applied continuously to the arsenical pyrites (as distinguished from the common and magnetic pyrites) of the district, the average monthly returns would show a yield of at least twenty-five dollars per ton. The marvel is that, with this rich gold-bearing ore within a day's journey of some of our opulent cities, the enterprise to make it available should be so utterly wanting.'

Mr. Cosmos Newbery continues his report as follows:—

'I have the honour to return to you the copy of Professor Chapman's letter on the gold ore of North Hastings, and to offer the following remarks:—

'The ore which he has under notice, an auriferous arsenical pyrites, resembles the pyritous ores of our gold fields in not giving up the gold it may contain to any simple mechanical treatment, but differs in having the gold held in combination, as he says he has reason to believe that it is, in the condition of an arsenide, while in the pyrites of our mines there can be no doubt that the gold exists as metallic gold. Numerous trials by others, as well as myself, have failed to give any evidence of gold in actual combination. In the majority of the samples examined the gold has been found in an extremely finely divided state. The fine powder, when examined by the microscope, is seen to be composed of irregular masses of gold and imperfect crystals. The masses, if not crystalline, are usually rounded, like alluvial gold; the rough ragged edges of the quartz gold is seldom found, except in the larger pieces which sometimes protrude from the crystals or masses of pyrites.

'The reason for the difficulty in amalgamating pyrites gold is, I believe, due to its being completely coated with the pyrites, which, even after grinding, adheres to it, and prevents its contact with the mercury. Mr. Skey, of the New Zealand Geological Survey, finds that much of the gold he has examined is not readily amalgamated by mercury, owing, he states, to a thin film of sulphide coating the gold. This film is so thin that it makes no difference to the colour or lustre of the metal. Perhaps some such film may exist on the gold in pyrites, and this supposition is to a certain extent confirmed by the fact that a better yield of gold can be obtained when pyrites are amalgamated in some solution, such as cyanide of potassium, which would dissolve this film and allow the mercury to come in contact with the particles of gold.

'The formation of arsenide of gold in quartz kilns and roasting furnaces has been noted here, and there can be no doubt that all gold so combined will be lost, as it is extremely brittle, and is therefore ground to a fine powder and washed away with the tailings.

'The treatment with nitrate of soda is one which I do not think applicable in this country; it will probably give an increased yield of gold, but the cost of this extra yield will be more than its value. By the present method of treatment, careful concentration of the sand, roasting, and amalgamation, about 80 per cent. of the gold in the pyrites is obtained. If we say the pyrites contains two ounces of gold per ton, this would give a loss at present of eight pennyweights of gold, worth 32s. (taking gold at 4*l.* per ounce). Now the amount of nitrate recommended is one-tenth of the weight of the ore to be roasted (2 cwt. per ton), worth in this country 24*s.* per cwt.; so that, without including extra labour, fuel, &c., the 32*s.* worth of gold would require 48*s.* worth of nitrate of soda. This is supposing the whole of the 20 per cent. now lost were to be recovered by the use of this salt, a result hardly to be looked for. This loss of 16*s.* per ton would have to be recovered from the arsenical pigments, which are at present of little or no value here. Tons of arsenic are taken from the flues of our pyrites furnaces and buried or thrown away, as there is no market for it.

'As mentioned in a memorandum recently forwarded to you, I think that, as our pyrites contain many valuable substances besides gold, it should be the aim of works established here to save some, if not all of them, and I have but little doubt that, as the knowledge of the great waste of sulphur forces itself upon the mine-owners and consumers of sulphuric acid, we shall soon have complete works established which will be able to treat our pyrites and utilise all their components, and thus save the colony many thousand pounds per annum.

'The average yield of gold of the pyrites, blanketings, &c., that have been operated on in Victoria, is 2 ozs. 15 dwts. 10·88 grs. per ton, and with abundance of sulphides of the like character, it would be unwise to discourage experiments that might lead to a more profitable treatment of them.'—*Progress Report by the Inspector-General of Mines of Victoria.*

Styrian Pyrites.—The pyrites of Styria are known to contain gold. H. Schwarz proposes as an easy method for separating this gold, to fuse 100 grams of the powdered pyrites with 46·6 grams of iron filings under a layer of common salt. When cold the fused mass is broken up, and the resulting FeS is dissolved in dilute sulphuric acid. The solution being filtered, the residue containing the sulphide of gold is washed, dried, and roasted on a tile, and 2 grams of pure lead added. This mixture is fluxed in a muffle furnace: a small button of lead is thus obtained, in which, after dissolving in aqua regia, the gold can be readily detected.—H. Schwarz, *Gold in Pyrites*; Dingler's *Polyt. Jour.*, ccxviii.

PYRITES, IRON, *utilised.* (Vol. iii. p. 673.) Since the duties of Sicilian sulphur have been increased, iron pyrites has been employed as a source of sulphur. These pyrites, where they can be obtained in large quantities and cheaply, are profit-

ably used. The residue of pyrites contains so large a proportion of iron that in the single establishment of Megger, Dr. HOFMANN says, the loss thus occasioned amounts to a million and a quarter francs, and there is great difficulty in finding room for them.

Dr. HOFMANN succeeded in utilising them in the following manner. The residues, after the extraction of the sulphur, undergo a systematic washing, the temperature of the water being 40° C. To the washings thus obtained salt is added in the proportion of one equivalent for each equivalent of sulphuric acid present in the liquid. The result is sulphate of soda, which is separated by cooling and crystallisation. This product has numerous industrial applications, especially in the glass trade and in soda manufacture, and it is obtained in the present case in sufficient quantities to cover the cost of all the operations. The mother-liquors remaining after the sulphate of soda has been separated contain chloride of zinc, salt, sulphate of iron and zinc, and a further quantity of sulphate of soda. By concentration to 54° B. the various salts are deposited, with the exception of the chloride of zinc, which may then be separated. This has several industrial applications, and is sold in Germany at 18½ francs per 100 kilos, and is much used for preserving railway sleepers, or it may be used for obtaining metallic zinc by being first treated with lime to convert it into oxide of zinc. The residue from the last operation still contains the iron originally present in the pyrites, and also some sulphur. It is dried for some days in the open air, and the bulk of it crumbles to powder, though there remains some compact fragments. Dr. HOFMANN found, as the result of his inquiries on the pyrites of Megger, that the portion in powder is almost free from sulphur, while the fragments still retain considerable quantities. Simple sifting serves to separate the part free from sulphur, and it is then ready for treatment as an iron ore.—*Les Mondes, Revue Hebdomadaire des Sciences*, June 17, 1875.

Burnt Pyrites. M. G. LUNGE.—According to the analyses of M. GIBB, the pyrites of San Domingo, of Tharsis, and Rio Tinto contain on an average 46 to 49 per cent. of sulphur:—

	Copper, per Cent.	Silver, Ounces per Ton
Rio Tinto	3·80	1·20
Tharsis	3·50	0·75
San Domingo	3·70	0·75

The burnt ores, as delivered by the sulphuric acid makers, have the following composition:—

	Rio Tinto	Tharsis	San Domingo	Ytteröen, Norway
Copper { calculated }	1·6500	1·6000	1·5500	1·01
Iron { as $Cu^2Fe^2S^4$ }	3·6400	3·2500	2·7600	3·33
Sulphur	3·5300	3·1500	3·0200	3·10
Oxide of copper	2·7500	2·5600	2·7000	0·39
Oxide of zinc	2·0200	0·5500	0·4700	0·46
Oxide of lead	0·4700	0·7000	0·8400	0·06
Silver	0·0037	0·0023	0·0025	—
Oxide of cobalt	0·0070	0·0320	0·0330	—
Oxide of bismuth	0·0130	0·0100	0·0130	—
Lime	0·2000	0·2500	0·2800	2·50
Oxide of iron	77·4000	77·0000	78·1400	68·06
Sulphuric acid (SO^3)	6·1000	5·2500	5·8000	6·56
Arsenic acid	0·2400	0·1700	0·2500	0·03
Insoluble residue	1·4500	5·8500	1·6500	8·74
	99·4700	100·2600	99·3200	100·06

M. G. LUNGE, *Bulletin de la Société Chimique de Paris*, June 5, 1876.

The Extraction of Silver from Cupreous Iron Pyrites.—The cupreous pyrites now imported from Spain in large quantities for the manufacture of sulphuric acid contains small proportions of gold and silver, and attention is now being paid to discover cheap means of separating these metals from the copper. After the sulphuric acid manufacturer has burnt off as much sulphur as he desires from the cupreous pyrites, the

residue is sent to the metallurgist. The relative proportions of copper and silver in residues from the chief varieties of pyrites are as follows:—

	Copper, per Cent.	Silver, per Ton
Rio Tinto	3·80	1 oz. 14 dwts.
Tharsis	3·60	15 "
San Domingo (Mason's) . . .	3·70	15 "

The process generally adopted for extracting copper from burnt pyrites consists essentially of three chief operations, viz.:—(1) Formation of chloride of copper by calcining the burnt ores with common salt; (2) separation of this chloride from the mass by lixiviation; and (3) precipitation of copper by metallic iron from the solution so obtained.

Silver and gold are chloridised in the calcination and dissolved with the chloride of copper, chloride of silver being dissolved in the first washings, which contain a comparatively large proportion of metallic chlorides, besides, in most cases, chloride of sodium.

When these solutions are digested on metallic iron, the silver and gold are precipitated with the copper, and many attempts have been made to separate economically the precious metals from the solutions before precipitating the copper, or from the copper after precipitation.

At first sight the problem appears easy; comparison with Augustin's process for extracting silver from copper regulus suggests at once digestion of the solutions on metallic copper, but before anything like complete separation is accomplished, the cupric chloride must be reduced to cuprous chloride, and when dealing with solutions in which the relative proportions of copper and silver are so extremely unequal (about 1,600 to 1), the slowness of the reduction of cupric chloride and the sparing solubility of cuprous chloride render the process quite impracticable. On this principle Claudet proposed to employ spongy iron slightly in excess of the proportion required to change the cupric to cuprous chloride, and Wagner to employ metallic copper in an extremely fine state of division. But the reduction of cupric chloride, even when spongy iron is used, is not easy on the large scale, and cuprous chloride is an extremely troublesome salt to deal with in large proportions in solutions.

In the beginning of 1870 a process was patented by F. Claudet and introduced by J. A. Phillips at the Widnes Metal Works (vol. iii. p. 678).

Claudet's process depends on the almost complete insolubility of iodide of silver in cold solutions of metallic and alkaline chlorides, and is conducted as follows:—In lixiviating burnt ores after calcination with common salt, Phillips has found that the first three washings contain about 95 per cent. of the soluble silver, and these washings only are run into settlers preparatory to silver precipitation; the remaining washings being treated directly for the copper they contain. After settling, the first liquors are run into precipitating tanks, a sample is taken from each tank and assayed for silver, and a quantity of iodide of potassium solution, calculated as equivalent to the silver found by assay, is added to the copper liquor. At the same time the liquor is diluted by about one-tenth its bulk of water and mixed with some milk of lime, whilst the whole is kept continually stirred. Iodide of silver, sulphates of lead and lime, and subchloride and oxychloride of copper, precipitate, and are allowed to settle during two or three days. From time to time the accumulated precipitate is removed, washed with dilute hydrochloric acid to remove the copper salts, and treated with metallic zinc, which decomposes the iodides with production of iodide of zinc and metallic silver and gold. The iodide is dissolved out, standardised, and employed instead of iodide of potassium in operating on further quantities of liquor. The composition of the residue is given by Mr. Claudet as under—

Silver	5·95
Gold	0·06
Lead	62·28
Copper	0·60
Oxide of zinc	15·46
Oxide of iron	1·50
Lime	1·10
Sulphuric acid	7·68
Insoluble residue	1·75
Oxygen and loss	3·62
	100·00

By the recovery of the iodine in combination with zinc, the cost for iodide is reduced

to that required to keep up the loss in carrying on the operations, and is only a small proportion of the value of the precious metals recovered. This process has been very successful in the hands of Mr. Phillips, who has recovered about two-thirds of the silver, and probably a larger proportion of the gold in the ores worked in the Widnes Metal Works since it was first introduced.

This process has been tried by other extractors, but has been by some abandoned. One cause of want of success appears to be the presence of cuprous chloride in the copper solutions. When ores, badly burnt or refractory, are calcined in handworked furnaces, or when a high temperature is employed in calcination, a considerable quantity of cuprous chloride is formed. The following testing of ores from different works shows the great difference in relative proportions of cupric and cuprous chlorides in calcined ores:—

	Per Cent.			
Cupric chloride	6·70	4·03	4·26	3·75
Cuprous chloride	Nil	0·21	0·45	0·62

When cuprous chloride is present in copper liquors in considerable quantity it is precipitated on dilution of the liquors, when iodide is added, increasing the quantity of precipitate, to be further dealt with to obtain the argentiferous residue; and in presence of cuprous chloride the silver is incompletely precipitated on addition of its equivalent of soluble iodide to the liquors. In the Widnes Works great care is observed to avoid the formation of cuprous chloride, and to this care the especial success of Claudet's process in these works is doubtless attributable.

A process adopted by the Bede Metal and Chemical Company, and continuously worked for a considerable time past, consists in the precipitation of the greater part of the silver, simultaneously with a comparatively small proportion of the copper, from the copper liquors by sulphuretted hydrogen. On first passing this precipitant into copper liquors a much larger proportion of the total silver than of the total copper in solution is precipitated. The first series of experiments, in which sulphuretted hydrogen produced by the ordinary laboratory method was employed, led to the expectation that with 10 per cent. of the copper 70 per cent. of the silver would be precipitated. But when H^2S, much diluted, was blown through the liquors, producing a violent agitation, a much more perfect concentration of the silver was obtained. In practice H^2S is obtained by the action of dilute hydrochloric acid on 'tank waste.' The tank waste is placed in covered tanks of wood 6 feet square and deep inside, on a bed of ashes over a false bottom of narrow boards. The acid is conducted under the false bottom, and rises through the waste to an overflow-pipe 2 feet 6 inches from the top, thus giving a large space for frothing, &c.

The sulphuretted hydrogen evolved in mixture with carbonic acid is drawn off by a blowing engine, and blown with a large quantity of air, purposely drawn in for dilution, through the copper liquors. Before blowing a sample is taken from each tank and tested for copper by standard cyanide of potassium solution. The blowing is allowed to go on usually for about twenty minutes, until a sample of the liquor gives 6 per cent. less copper than the first sample. All the liquor produced in lixiviating the ores is treated by this method, and boys, testing without any analytical training, are able, with the aid of a table, to come very near the precipitation of any percentage of copper that may have been decided on. The precipitate is allowed to settle, and the liquors are drawn off to the copper precipitating tanks. The precipitate is run off into washing-tanks, where as much of the copper solution is removed as is practicable, and the precipitate is at last collected in a filter on the Needham and Kite plan, but with chambers of more than twenty times the usual capacity.

The following are the average testings of the liquors and precipitate.—

	Copper per Litre, Grams	Silver per Ton of Copper, Ozs. dwts.
Original solutions	20·1	18 0
Desilverised solutions	18·8	2 19
Precipitated by H^2S	1·3	20 0

The washed argentiferous sulphide is not quite free from chlorides, and in the next operation—viz., calcination at a low temperature—chlorides of silver and copper are produced with oxide and sulphate of copper. The calcined precipitate is ground to a rough powder and lixiviated, first with water, which dissolves the sulphate of copper, with only a trace of silver, and subsequently with hot solution of common salt, which dissolves out the chloride of silver. The latter solution always contains copper and some sulphate of lead. This solution is mixed with milk of lime and the precipitate

well washed, to free it as far as practicable from chloride of calcium, after which it is digested in dilute sulphuric acid to separate the oxide of copper, and again washed. After drying the residue has the following composition:—

Silver	8·77
Oxide of lead	26·66
Oxide of copper	3·75
Peroxide of iron	2·61
Lime	13·07
Sulphuric acid	31·72
Chlorine	4·70
Water	4·20
Insoluble residue	1·40
	99·48

The method described of separating the silver from the precipitated sulphide of copper is somewhat complicated, but it has been adopted, after several modifications, as the most economical. The quantity of material to be treated in the latter operation being comparatively small, requires very few men and otherwise is not expensive.

The proportion of silver recoverable from burnt ore—about 1 part from 60,000—although extremely minute, yet amounts in value in Tharsis and Mason's ores to 2s. 6d. per ton, whilst the cost of extraction by either Claudet's process or the process last described is about 10d. per ton of ore worked; and when it is considered that 350,000 tons of such residues are produced annually, the aggregate value of the precious metals recoverable by these processes cannot be regarded as unimportant.

Roasting Pyrites.—In the article given in vol. iii. p. 673, there are descriptions of several processes for roasting pyrites, and of the processes adopted in the treatment of the cupreous ores. To these we have to add a description of Phelps's oxidising furnace.

The arrangement is very simple, and will be readily understood by the aid of the annexed engraving. *Fig.* 2467 is a vertical central longitudinal section, showing the arrangement of the 'terraces,' 'inter-terrace air-slots,' and 'sub-terrace air-chambers' (the object of which will be presently explained). A is the fire-box; B the ash-pit; C the oxidising flue, 4 feet in width, 40 feet in length, and inclined about 50°; E is a dust-chamber, communicating by the throat with damper, F, with the chimney, G; H is the arch into which the hot ore-pipe, I, conveys the ore; J, air-box with damper conveying air from fans to the sub-terrace air-chambers, O O O; K is the hopper; L the feed-roller; M M, terraces of fire-clay; N N, inter-terrace air-slots; P, feed-slot; S, discharge. *Fig.* 2468 is a transverse section of the hopper and feed-roller. *Fig.* 2469 enlarged view of the terraces.

2467

2468

2469

The time required to desulphurise a single particle depends greatly on its size, a little difference in superficies making a great difference in the time required; if a cube of pyrites 1 millimètre across its faces required ten seconds, one 2 millimètres square will require eight times as long, and so on; this is self-evident, for the simple reason that its contents are eight times as great. Hence the advantage of pulverising the ore very finely before roasting. But one of the difficulties where gold and silver are concerned has been that if very finely pulverised, a considerable quantity of

the finest ore (and the gold and silver with it) is drawn off by the force of the draught current. This difficulty Dr. PHELPS conceives he has overcome by introducing the ore in the lowest stratum of the draught current, so that it falls down the terrace floor of the inclined flue in a substratum of atmospheric eddies, caused by the meeting of the currents of air from beneath the terraces with the draught proceeding to the shaft.

The mode of working is as follows:—A gentle current of air passes out from beneath the foot of each step or terrace from the reservoirs. Each current thus enters the flue in a descending direction, and, coming in contact with the ascending or draught-current, creates a series of eddies immediately over the terraces and in the path of the ore. This arrangement supplies a vast quantity of air, in addition to that coming from the fire-box, without carrying the fine gold out of the furnace by the force of the draught-current.

The ore is pulverised dry and passed through a sieve having forty meshes to the linear inch, is then conveyed by strap and bucket elevators to the hopper, from whence it is discharged into the flue *underneath* the draught-current. As it falls from terrace to terrace it receives a fresh supply of oxygen from the incoming currents of air; is burned 'in suspension' thirty times over, in a constantly increasing temperature, and on leaving the furnace falls into another powerful current of air, and is blown through a long zigzag pipe, and is thus repulverised while hot and burning, preparatory to amalgamation.

Dr. PHELPS does not give any of the practical results of this furnace beyond stating the very large returns which it is capable of affording. The principle appears sound, and might well be adopted experimentally in this country in alkali works, where fine Spanish ore is burnt. The cost of construction will, however, it is to be feared, operate against its introduction. But perhaps the inventor will, like some other inventors, kindly spend more of his capital in showing the users the manner in which the process can be made commercially profitable.

PYRITES IN NORWAY.—The Wingnaes Mines of Norway, from whence some of our coppery pyrites come, are situated in the Island of Karmo, on the west coast of the Scandinavian peninsula. It was discovered in 1865 by M. DEFRANCE, a French engineer. The beds of pyrites are described by M. F. KUHLMANN, jun., as being in contact with metamorphic schist on one side and on the other with *gabro*, known as hyperite and euphotide, composed of a granular mass of labradorite strongly impregnated with smarage and diallage. It contains rock crystal, titaniferous iron, and garnets. The ore is generally composed of sulphide of iron mixed with sulphide of copper and furrowed with blend. The gangue is silica, with a little fluorspar and chlorite. Traces of carbonate of lime are also found. The average proportions are—

Sulphur	46 per cent.
Copper	3 "

though certain portions contain from 12 to 14 per cent. of that metal. Specimens of metallic copper are sometimes found. Silver and gold occur in very small quantities. Of arsenic there is not a trace, which is important to the sulphuric acid manufacturer.

The Utilisation of Waste Products from Iron Pyrites.—P. W. HOFMANN, in DINGLER'S *Polyt. Jour.*, February 1, 1875, gives the following description of processes used for this purpose:—

'After iron pyrites has served for the manufacture of sulphuric acid it is difficult to dispose of the refuse, which contains much that is valuable, and if not used, must be carefully prevented from contaminating streams. At Meggen, where most of the German sulphuric acid is manufactured, nearly 100 waggons of pyrites are daily used, corresponding to 70 waggons of ironstone, containing 40 per cent. of iron, which may be roughly valued at 50,000*l*. Many unsuccessful attempts have been made to utilise the iron, but the sulphur still mixed with it renders the metal altogether useless. All efforts to remove it by heating have failed, probably by reason of the many elements contained in the waste product; chemical analysis demonstrating the presence of sulphur, iron, selenium, arsenic, lead, mercury, thallium, &c., while sometimes zinc, in the form of sulphate, occurs to the extent of 8 per cent.

'Iron pyrites, when heated to a high temperature, soon parts with the sulphur, but if sulphate of zinc is formed, very great heat is necessary to effect this separation: it is the creation of this sulphate that has long stood in the way of utilising the refuse. Soaking the refuse in water, evaporating to dryness, and thus securing crystallised sulphate of iron, is easy enough; but as the product contains a large quantity of sulphate of zinc, it is of little commercial value, for the separation of the two compounds is practically impossible. The difficulty may be overcome, however, if the liquid in which the refuse has been soaked is treated with an equivalent of common

salt for every equivalent of sulphuric acid. On cooling this liquid, crystals of Glauber salts are formed, in such quantity as will pay the expense of working the refuse. The liquid, moreover, contains chloride of zinc, with a greater or less amount of common salt, besides the sulphates of iron and zinc and sulphate of soda. By concentrating the liquid and evaporating, all the salts are separated, leaving pure chloride of zinc in the solution, which may be sold at 7s. 6d. per cwt. Thus two valuable products are obtained from the waste pyrites.

'The waste solids, when thrown on one side after the soaking operation, crumble for the most part into dust, the harder portions still containing sulphur in large quantities. By sifting, it is possible readily to separate the sulphur material from the remainder.

'The author states that this method of utilising the waste from iron pyrites is not a theoretical one, as many thousand hundredweights of the materials have already been operated upon, and several hundredweights of the Glauber salts and chloride of zinc have been produced in this way and profitably sold.'

Dr. C. R. A. Wright read a paper before the Society of Arts, from which we are glad to extract some valuable information collected by him with exceeding industry.

The following table gives a general idea of the composition of some of the various kinds of pyrites in practical use, derived from various localities. Of these the first mentioned (Huelva and Tharsis ores) possess the greatest amount of practical importance, on account of the extent of the natural deposits, the scale on which they are worked, the amount of copper contained, and the large and increasing quantities of metallic copper now actually extracted from them:—

Locality	Huelva and Tharsis			Belgium	Cornwall	Wicklow		Westphalia	Pomerania	Sweden
Analyst	Clapham	Wedding and Ulrici	Wright (average)	Clapham	Clapham	Thompson	Wright (average)	Pattinson	Bidwell and Marreco	Bidwell and Marreco
Sulphur	47·50	48·90	49·07	47·50	34·64	47·41	30·84	45·60	48·73	39·05
Iron	41·40	42·25	44·28	39·70	32·20	41·79	—	38·82	42·05	42·50
Copper	4·21	3·10	3·74	—	6·30	1·95	1·29	—	5·87	1·60
Arsenic	0·33	0·47	0·30	0·20	0·01	2·11	—	trace	trace	—
Zinc	0·22	0·35	—	0·40	1·82	2·40	—	4·90	—	—
Lead	1·22	0·93	—	0·02	0·40	—	—	0·64	—	—
Silica (quartz, sand, &c.)	3·49	3·70	2·04	8·66	23·90	3·98	—	8·71	2·30	12·16
Oxygen, alumina, lime, and matters not determined	0·90		1·15	10·12	1·66	0·94	—	0·04	2·20	0·40
	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The use of pyrites, copper pyrites, and analogous minerals, such as zinc blende, in the manufacture of the different 'vitriols' (green vitriol or ferrous sulphate, blue vitriol or cupric sulphate, and white vitriol or zinc sulphate) is of considerable antiquity, these salts having been known from an early period as being produced by the natural or artificial oxidation of these sulphur-containing minerals; and the use of copper pyrites, galena, and zinc blende as sources respectively of metallic copper, lead, and zinc, and their alloys, also dates from a comparatively early epoch. Moreover, it has long been known that when pyrites are heated in open vessels, so as to allow free access of air, sulphur dioxide is formed, whilst more recently it has been found that when the heating is effected in closed vessels, sulphur is expelled as such, and may be collected by means of suitable condensing arrangements. It is, indeed, not improbable that some at least of the sulphur found in the free state in volcanic districts is actually derived from this source in this way, although a considerable portion of such natural sulphur is probably formed by the mutual reaction of gaseous sulphuretted hydrogen and sulphur dioxide, water and free sulphur being produced thus:—$2SO^2 + 4H^2S = 4H^2O + 3S^2$. As mentioned below, advantage has also been taken of this change to obtain sulphur from pyrites commercially; one portion of the mineral being heated in contact with air so as to form sulphur dioxide by the combustion of the sulphur present, another being so treated as to give rise to sulphuretted hydrogen.

The most important use of pyrites, however, as a substitute for sulphur, consists in its employment on the large scale as a means of producing sulphur dioxide for the

manufacture of sulphides, hyposulphites, sulphates, antichlors, disinfectants, &c.; and principally for the production of sulphuric acid and its derivatives. The use of pyrites for this purpose, instead of sulphur, appears to have been first put in operation on the large scale in this country by HILL, of Deptford, as early as 1818. One disadvantage attending the substitution of pyrites for sulphur in the vitriol manufacture is, that to produce a given amount of vitriol, more chamber space must be allowed. When sulphur only is burnt, the resulting sulphur dioxide is diluted only with that amount of nitrogen (leaving out of consideration unchanged air) associated originally with the oxygen of the sulphur dioxide; but when pyrites is burnt, the resulting sulphur dioxide is diluted not only with this amount of nitrogen, but also that originally associated with the oxygen taken up by the iron of the pyrites. The reactions by which the sulphur dioxide is formed are respectively indicated by the equations—

$$4S^2 + 8O^2 = 8SO^2,$$

$$4FeS^2 + 11O^2 = 8SO^2 + Fe^2O^3;$$

i.e., the quantities of air requisite for burning sulphur and pyrites respectively, so as to produce the same amount of sulphur dioxide in each case, are in the proportion of eight to eleven. Another disadvantage is the much greater degree of impurity of the acid made from pyrites, owing to the volatilisation and mechanical carriage of various substances from the pyrites burner to the vitriol chamber. Of these substances arsenic is by far the most objectionable, whilst iron, zinc, thallium, selenium, &c., are frequently introduced into the vitriol. For many practical purposes these impurities are not of any consequence, but the impregnation of sulphuric acid with arsenic produces as a final result the contamination of a large number of chemical products with that deleterious substance. Saltcake, hydrochloric acid, soda ash and crystals, soap, and many other products requiring the manufacture of sulphuric acid as a step to their production, frequently contain traces and even more of arsenic derived from this source; and the widespread presence in many substances of household use, and even articles of food and medicine, of this objectionable ingredient, is in all probability not without influence on the general health of the population, besides lending additional complications in the detection of arsenic in toxicological investigations.

It is unnecessary to review in detail the various improvements made during the last half century in the apparatus employed in the production of oil of vitriol from pyrites, and in the method of practically carrying out the manufacture. Experience shows that a slightly different form of kiln or pyrites burner is requisite, according to the nature of the sulphur ore used, in order to carry the combustion to the furthest possible extent. Slaty ores, like Wicklow pyrites, require much deeper kilns than ores containing little earthy matter like Huelva pyrites. Ores containing more than traces of lead are very apt to flux or frit more or less, thus glazing and agglomerating the lumps, and rendering perfect combustion difficult or impossible. The same result may follow if the temperature in the kiln rise too high with certain other kinds of ores, the lower sulphides of iron first produced and the clayey and earthy matter present being frequently fusible at a sufficiently high temperature. Ores containing much earthy matter (such as Wicklow pyrites, which practically consists of a slaty mass through which pyrites is disseminated) are more difficult to burn, so as to utilise nearly the whole of the sulphur present, than ores containing little quartz or other earthy matters, such as Huelva pyrites; in any case it is practically impossible to utilise the whole of the sulphur present. On an average, 100 parts of Huelva (or other analogous) ore, containing 48 per cent. of sulphur to start with, will yield, when burnt as thoroughly as is practicable on the large scale, about 70 parts of residual iron oxide, containing (besides the copper, &c., originally present) about 2·5 to 3·0 per cent. of sulphur, partly as a cupriferous kernel in the centre of each lump. Not unfrequently, however, the amount of sulphur present considerably exceeds this amount, owing to inefficient treatment during the burning of the pyrites. Hence about 2 parts of sulphur per 100 of original ore remain unburnt, or 4 parts of sulphur per 100 of sulphur originally present are unutilised. With such ores as Wicklow pyrites, containing only about 30 per cent. of sulphur to start with, a much larger quantity remains unburnt. One hundred parts of such ore, as usually burnt in the kilns, yields about 80 parts of burnt ore, containing on an average about 5 per cent. of unburnt sulphur (for the most part contained as green or unburnt mineral forming the core of the larger fragments, the smaller fragments and dust usually not containing more than 2 or 3 per cent. of sulphur, owing to the combustion being less injured by the earthy admixtures in the case of smaller pieces). Hence about 4 parts of sulphur per 100 of original ore, or 13 parts per 100 of original sulphur, remain unutilised. *Ceteris paribus*, the more free from earthy admixtures is the pyrites used, the less is the amount of sulphur lost by being left in the burnt pyrites. Of

the portion thus left part is present as a basic persulphate of iron, part as sulphate of lime, &c., according to the nature and amount of the earthy matters present in the original ore.

The amount of sulphur left behind in the burnt ore from a given class of pyrites necessarily varies with other circumstances, such as the exact size and shape of the kilns, the methods of stoking and of removing burnt ore, and of supplying green ore, and notably with the duty performed by each kiln—*i.e.*, with the quantity of pyrites passed through it in a given time; thus I have obtained the following average numbers as the results of several months' working on a uniform quality of pyrites (Huelva), 25 to 30 tons of pyrites being burnt daily :—

Cwt. of Pyrites per Kiln per Diem	Percentage of Sulphur in Burnt Pyrites
5·8	2·85
6·8	2·88
7·0	3·01
7·5	3·08

PYROLETER. The name given by the inventors, Messrs. Paton and Harris, to a machine to be used for the extinction of fire on board ships.

The pyroleter is a small double pump worked by hand, which sucks up from tubes on either side muriatic acid and a solution of carbonate of soda. These mingle in a generator forming part of the pump. The carbonic acid gas formed and the solution of salt and acid pass at once down a metal pipe to the hold; along the keelson of the ship runs a perforated wooden box, which admits the dry carbonic acid gas amongst the burning materials.

The *Chemical News* for June 18, 1875, describes an experiment.

'A well-appointed steamer conveyed the party from Blackwall to Greenhithe, where a large barge had been prepared. Its entire hold was covered to a depth of several feet with wooden shavings and cotton-waste saturated with turpentine and naphtha. A temporarily raised, and by no means air-tight, wooden deck, with loosely fitted boards, formed the wide hatchway covering. After the apparatus had been explained by Dr. R. Carter Moffat, in respect to its action as a common wash-deck pump and fire-engine, and its influence for a fire above-board had been observed, upon which it acted very efficiently, throwing water a distance of 30 feet, the pipes containing chemicals were attached, and the signal given to set fire to the inflammable materials in the hold. Immediately, the flame ran along the entire cargo, and issued above the temporary deck, which was then covered with boarding. The "pyroleter" having been brought into action—and although nearly half a gale of wind was blowing—the fire was completely extinguished in four minutes.'

It is, we understand, computed that a 1,200 ton ship requires about half a ton of each—the muriatic acid and carbonate of soda—which, with their packages, will cost about 20*l*.

PYROMETER. (Vol. iii. p. 680.) See Iron and Steel, p. 467, for a description of Mr. Hobson's pyrometer for the hot-blast.

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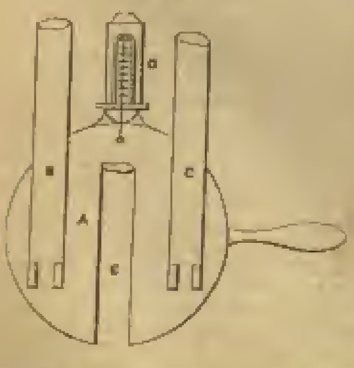

Bradbury's *Pyrometer*, which is also used for measuring the temperature of hot-blast, is represented in the following figure. Mr. W. A. Bradbury published in *Iron* the following description :—

'This pyrometer consists of a hollow sphere, A, through which are two tubes, B and C, for conducting the hot and cold blasts respectively. In any convenient position is a case, D, for the reception of the thermometer. It contains a transparent face, to allow the temperature to be read off without withdrawing the thermometer from A. The tube, E, has an area equal to B and C, and is for conducting off the mixed blasts.

'The principle of the instrument is based on the calorimetric method, known as the "Method of Mixtures."

'When pressure communicates motion to a body, the accelerating force varies directly as the pressure, and inversely as the mass. The product of the accelerating

force and the mass is termed the *moving force*. Let f denote the accelerating force, P the pressure, and M the mass, then—

$$f \text{ varies as } \frac{P}{M}$$

$$\therefore Mf \quad ,, \quad P$$

Hence the above law may be enunciated in the following way: When pressure communicates motion to a body, the moving force varies as the pressure.

'As the pressure is the same on both the hot and cold blast tubes, H and C, it follows that the moving force is the same, consequently the same weight of either hot or cold blast will travel from the same point of rest, over the same space in the same time. Hence from equal orifices equal weights of either hot or cold blast will be delivered. If the cold be n times hot-blast pipe area, and x the weight of one part of hot-blast, the total cold-blast delivered will be nx.

'It is quite immaterial what unit of weight be taken as the standard, as the ratio is always constant.

Let x = the weight of hot blast delivered.
,, n = area of hot-blast pipe taken n times.
,, nx = weight of cold blast delivered.
,, t° = temperature of cold blast.
,, T = temperature of hot blast.
,, m = temperature of mixed blasts.

Then by method of mixtures—

$$T = \frac{mx + mnx - nxt}{x} = m + mn - nt.$$

If the area of the cold-blast pipe be nine times that of the hot, there will be nine times the weight of cold air to one of hot delivered.

$$\therefore T = m + 9m - 9t = 10m - 9t.$$

Hence the temperature of the hot blast is found by taking ten times the mean temperature less nine times the temperature of the cold blast, *i.e.* when the above dimensions are taken.

'To use the instrument, the cold blast is attached to C, and when the thermometer is constant, the temperature is read off. The hot blast is now attached to H, and a second reading taken, when the temperature is constant. These are all the data required to calculate the temperature of the hot blast. The only precaution necessary is to have the distances equal that are described by the hot and cold blasts respectively.

'The expansion of the tube H is so small that it can be disregarded, the expansion of wrought iron for 1° C. being about 0·000012204.

'This pyrometer complies with its requirements, viz.: (1) Its indications will be constant for the same temperature, because the hot and cold blasts are acted on by the same force—consequently the ratio is always constant. Also there is no change due to gradual chemical or physical causes. (2) Its indications at different temperatures are related to each other according to a well-known law—the law of mixtures. (3) Every instrument will be uniform in its indications, because they are governed by the same laws; also, it is not necessary that they be compared with or graduated by each other or a standard.'

MAIN'S *Pyrometer* is the invention of Mr. ROBERT MAIN, of Glengarnock Ironworks. This pyrometer consists in an arrangement of apparatus wherein the temperatures indicated on a mercurial thermometer or pyrometer bear a known relation to the actual temperature of the blast itself, so that, the numerical relation being ascertained, the readings of the mercurial thermometer or pyrometer indicate the actual temperature sought to be measured. The temperature of the blast is, of course, too high to be directly measured either with a thermometer or pyrometer, the high temperature either rendering the indications inaccurate or destroying the instrument when directly applied. The thermometer must therefore be protected, which is done as follows:—The apparatus constituting this invention consists of a hollow chamber, preferably double cased, the space between the casings being filled with asbestos, or other substance of low conducting power. This chamber is placed at any required distance from that point of the hot-blast main in which it is desired to ascertain the temperature, and is connected thereto by a tube of ⅜-inch diameter, which conducts the hot blast into the chamber. The distance for a blast of 800° to 1,000° Fahr. need not exceed 6 feet. The chamber is also provided with an exit through which the hot

blast escapes. The chamber may contain a second smaller chamber or receptacle in which the thermometer or pyrometer is placed. In the case of using a large pipe for conveying the blast, the chamber arrangement may be dispensed with, in which case the thermometer or pyrometer is placed in a hole in the pipe.

PYROPHONE. A name given by M. KASTNER to a new instrument, which produces musical notes by the use of ordinary coal gas. Ordinarily, singing flames have been produced by hydrogen gas, but M. KASTNER has shown that carburetted hydrogen may be used, and he has drawn the attention of the *Académie des Sciences* to some curious facts in connection with the phenomena of singing flames. M. KASTNER writes:—

'In the experiments which I have made, introducing two separate flames, produced by combustion of ordinary gas, into a glass tube, I could not obtain any sound; this was proved by numerous trials to be due to the presence of carbon in these flames. . . . It was necessary, therefore, to eliminate the carbon in some way; and I arrived at this result as follows:—

'When the flame is merely illuminating (that is, when the air in the tube does not vibrate), it presents an elongated form, with the upper end pointed. It also shows a swelling about the middle, and it is without rigidity, obeying the least current of air, which makes it flicker in one direction or another.

'On the other hand, when the flame is sonorous, that is, when it determines in the tube the vibrations necessary for production of sound, its form is narrowed and thin like a plume, and swelling out at the top. While the air of the tube vibrates it is highly rigid; the carbon is in great part eliminated by a mechanical process.

'The sounding flames produced from ordinary gas are, in fact, surrounded by a photosphere, which does not exist when the flame is simply luminous. In the latter case, the carbon burns in the flame, and contributes in large proportion to its illuminating power.

'But when the flames are sonorous, the photosphere surrounding each of them contains a detonating mixture of hydrogen and oxygen, which causes vibrations of air in the tube. For the sound to be produced in its full intensity, it is necessary and sufficient that the whole of the detonations produced by the molecules of oxygen and hydrogen, in a given time, be in accord with the number of vibrations which correspond to the sound produced by the tube.

'To put these two quantities in accord, I increased the number of flames, so as to increase also the number of detonations of the mixture of oxygen and hydrogen in the photospheres, and so cause vibration of the air in the tube. In place of two flames of pure hydrogen, I placed four, five, or six ordinary gas-burners in the same tube. I observed that the higher a flame is the more carbon it contained. I therefore first diminished the height of the flames, and then increased their number, so as to obtain a total surface of different photospheres, sufficient to produce vibration of air in the tube. The quantity of carbon contained in the whole of the small flames will always be much less than the quantity which would correspond to two large flames necessary to produce the same sound. In this way I have succeeded in obtaining sounds the timbre of which is as distinct as with hydrogen gas. Whenever the flames, or rather the photospheres corresponding to the flames, are brought into contact, the sound immediately ceases.

'The carbon of ordinary gas, when the flames are sonorous, is certainly eliminated almost *in toto*. It forms on the internal surface of the resonant tube, at the height of the flames and below them, a perceptible deposit of carbon, which increases as the air of the tube continues to vibrate. I am able to say, then, that the pyrophone is capable of acting as well with the combustible gases contained in ordinary gas, as with pure hydrogen.'

PYROSCHISTS. A name proposed by Dr. STERRY HUNT for the bituminous shales of the coal-measures of the United States of America.

PYROTECHNY. (Vol. iii. p. 682.) *Coloured fires.*—SERGIUS KERN, of St. Petersburg, finding it to be necessary to know the quickness of burning of coloured fires, instituted some experiments to determine the rate of burning of sundry compositions.

He prepared the following Tables for the red, green, and violet compositions, where every formula with a higher number burns quicker than a fire with a lower number. The compositions employed were, it will be seen by the headings given in the tables, such as are used by the firework manufacturer. The colouring matter of the flame may of course be varied, and in most cases without in any way altering the results given, that is, if the combustible agents are made to agree with the number given in the first column of each table:—

Green-coloured Fires.

	Chlorate of Potassium	Nitrate of Barium	Sulphur
Number	Per Cent.	Per Cent.	Per Cent.
1	36	40	24
2	29	48	23
3	24	55	25
4	21	57	22
5	18	60	22
6	16	62	22
7	14	64	22
8	13	66	21
9	12	67	21
10	11	68	21
11	10	69	21
12	9·5	69·5	21
13	9	70	21
14	8·5	70·5	21
15	8	71	21

No. 5, for example, burns quicker than No. 6, and slower than No. 4, and so of the others.

Red-coloured Fires.

	Chlorate of Potassium	Nitrate of Strontium	Sulphur	Powdered Carbon
Number	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1	40	39	18	3
2	32	46	19	2
3	27	51	20	2
4	23	55	20	2
5	20	58	20·5	1·5
6	18	60	21	1
7	16	61·6	21·2	1·2
8	15	63	21	1
9	13	64	22	1
10	12	65	22	1
11	11	66	22	1
12	10	67	22	1
13	10	67·25	22	0·75
14	9·25	68	22	0·75
15	9	68·35	22	0·65

Violet-coloured Fires.

	Chlorate of Potassium	Carbonate of Lime	Malachite Powdered	Sulphur
Number	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1	52	29	4	15
2	52	28	5	15
3	52	26	7	15
4	52	24	9	15
5	52	23	10	15
6	52	21	12	15
7	51	20	14	15
8	51	18	16	15
9	51	16	18	15
10	51	15	19	15
11	51	13	21	15
12	51	11	23	15
13	51	10	24	15
14	51	8	26	15
15	51	6	28	15

—*Chemical News*, September 22, 1876.

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QUARTZ. The colour of *Smoky Quartz* has been attributed by FLECKHERS to organic matter. FORSTER confirms this view. He finds that when smoky quartz is subjected to dry distillation, it yields a quantity of a brown liquid which contains carbonate of ammonia. It therefore appears that the colour is due to an organic body containing nitrogen.—POGG. *Ann.* cxliii. p. 173.

QUEBRACHO WOOD (*Aspidosperma*). About twenty-five species of these trees are known in tropical America. The wood is valuable and used for many purposes. The *Aspidosperma excelsum* is called the 'paddle-wood,' and is used by the natives for building boats. A new extract from the Brazilian *Quebracho wood* is now being introduced by DUBOSC, of Havre, as a substitute for catechu, sumach, and the like.—REIMANN'S *Färber Zeitung*.

QUICKSILVER. The *Alta California*, in an article assuming the probable suspension of several of the productive quicksilver mines unless there is soon an improved demand for metal, with consequent increase in value, says:—

'The New Almaden is producing about 900 flasks per month; the Redington 800; the New Idria 500; the St. John and the Great Western each 400, and others less. The yield of the New Almaden and New Idria, south of the Bay, is equal to that of the others in Solano and Napa counties. The smaller mines north of the Bay are much more productive than those to the south of it. The St. John's mine is putting up a new furnace, and will contend for the second place with the Redington next year.'

On October 1, 1876, the stock held by the ROTHSCHILDS in London was supposed to be 3,400 flasks. There was no Australian, and only about 300 flasks of Italian quicksilver in the market. The supply, therefore, exceeded but little the usual monthly consumption of England for export and home use, which may be put down at 3,500 flasks. The production, outside of California and Mexico, is ascertained to have been as follows in 1874:—

Spain	36,000 flasks
Austria (Idria)	8,000 "
Italy	2,700 "
Germany	2,100 "
Borneo	2,000 "
Total	50,800

It is estimated that the production for the year 1876 was very nearly about the same amount. The yield of California is valued at 40,000 flasks, and that of Mexico at 2,200. This would raise the world's supply for 1876 to 93,000 flasks. The world's consumption varies between 80,000 and 90,000 flasks, according to the price of the metal. The greater the decline the more consumption is stimulated thereby, since less valuable ores can then be treated to advantage.

The California exports from January 1 to October 1, in the years named, were returned as follows:—

By Sea	1874 Flasks	1876 Flasks
To New York	75	257
Mexico	2,825	3,220
Chili	404	355
New Zealand	41	183
Bolivia	134	—
China	300	11,298
Japan	161	700
Central America	9	17
British Columbia	2	17
England	—	100
Other South American places	200	2,024
Australia	—	415
Calcutta	—	10
Asiatic Russia	—	5
Overland	—	2,800
	4,151	21,395

The lower value of this metal in the year 1876 especially stimulated export to China, and it is difficult to determine what China may absorb at a certain price.

It is stated that the London merchants have retained the control of 35,000 flasks out of the 93,000 produced in 1876; the rapidly increasing yield of California tends to remove the control of the market from London to San Francisco, where it is again regulated by the demand from China. Although the telegraph links all these places, the real future of values turns upon California production, and not upon speculative combination at either centre, for the growing magnitude of the Californian yield has become overshadowing.

The production of California in 1876 was unprecedented, amounting to 70,000 flasks.

Receipts	63,928 flasks
Exports	42,010 „

It is thought that about 6,000 flasks were shipped direct from the mines to Nevada which must be added to the above receipts.

China took	24,595 flasks
Mexico „	7,041 „
New York „	6,213 „

Another return gives California as producing 60,000 bottles, and Almaden 25,000 bottles, and the total consumption of the world as about 100,000 bottles.

The importations into this country in 1875 and 1876 are returned as follows:—

Countries	1875		1876	
	Bottles	Value	Bottles	Value
From Germany	89,627	£13,013	148,046	£16,148
„ Portugal	2,731,725	589,141	2,350,753	314.676
„ Italy	242,154	42,474	208,434	25,000
„ Austrian territories . .	73,472	14,340	—	—
„ United States of America .	51,023	9,070	87,700	8,120
„ other Countries . .	9,085	1,316	47,986	5,709
Total . .	3,196,786	£669,354	2,843,918	£369,762

QUINIZARIN. 'This substance was first obtained by GRIMM according to BAEYER's method, the action of anhydrous phthalic acid upon phenols, i.e. in this case by heating a mixture of hydroquinon phthalic acid and sulphuric acid. If the melt is heated to 130° to 140° C., two bodies are formed—a phthalein similar to phenol-phthalein, and a red colouring matter isomeric with alizarin. In order to isolate the latter body, quinizarin, in a state of purity, the crude melt is extracted first with boiling water and then with absolute alcohol, the latter extract being then precipitated with water. Or the melt is treated with benzin (boiling point 110° to 120°), which dissolves quinizarin readily, and phthalin but sparingly. It is purified by crystallisation from alcohol and ether. Not merely hydroquinon, but all substances which produce it, when heated with sulphuric acid, yield quinizarin. Such, e.g., is the behaviour of quinic acid, which, if heated with sulphuric acid, yields α-bisulphohydroquinonic acid: further, the thiochromate of potassa, from which GRAEBE's β-bisulphohydroquinonic acid is first formed. The sulpho-acids themselves yield this compound; but it is remarkable that the two isomeric bisulpho-acids produce exactly the same quinizarin. If we assume that, on the displacement of the two sulpho-groups, phthalein takes their place, we must conclude from this behaviour that one of the two isomeric bisulpho-acids, on heating with sulphuric acid, is converted into the other.

'Quinizarin crystallises from ether in orange leaflets, but from benzin and alcohol in deep red needles. From the alcoholic solution it is precipitated in yellowish-red flocks on dilution with water, which, if heated to 100° to 110°, become dark red and crystalline.

'The solutions in ether and sulphuric acid are distinguished by a greenish-yellow fluorescence. The ethereal solution appears brownish-yellow by transmitted light: the sulphuric solution has a peculiar violet colour, which, on dilution, passes into a pale onion-red. A similar fluorescence is displayed by the munjistin obtained by STENHOUSE from rubia munjith, a compound which possibly stands in the same relation to quinizarin as does purpurin to alizarin.

'When heated, quinizarin sublimes in paler or darker needles and plumose crystals resembling alizarin, whilst a shining carbon is left behind. The melting-point of the

sublimed body is from 194° to 195°; that of the crystals obtained from alcohol, 192° to 193°.

'With alkalis, quinizarin yields blue solutions, with a faint violet cast; the ammoniacal solution displays a violet colour. It is most distinctly produced by the alkaline carbonates. With baryta this dye forms a beautiful violet-blue compound; with alumina it yields a red lake, with a violet cast; the magnesium compound is a deep violet blue. The faintly alkaline solution is precipitated of a brownish-red by ferric chloride, and of a dull red by sugar of lead.

'If the alcoholic solution is allowed to stand for some time, it becomes gradually decolorised, whilst a deep blue violet—sometimes black—precipitate is deposited, which redissolves in alcohol with a blue colour. At a boiling heat the alkaline solution is decolorised by zinc powder, but resumes its original colour on exposure to the air.

'Quinizarin is not merely isomeric with alizarin, but is most closely related to it, since it is a derivation of anthracen differing merely in the position of the hydroxyls (1·4), which, in alizarin, are 1·2. If the vapours of quinizarin are passed over heated zinc powder, we obtain white shining leaflets, melting at 210° to 212°, and forming, with picric acid, a red compound. If treated with glacial acetic acid and chromic acid, they form a compound capable of sublimation, melting at 273°, and having the exact appearance of anthraquinone.

'Quinizarin behaves with aluminous and iron mordants differently from alizarin. It dyes with difficulty, and produces quite different shades. With aluminous mordants it gives a faint bluish rose, and with iron a slate grey. But with a mixture of both—the mordant for alizarin brown—it gives tolerably vivid violet shades, which do not, however, equal the beauty of alizarin violet.

'The ethereal and sulphuric solutions of quinizarin display several characteristic absorption bands.'—*Anthracen*, by G. Auerbach, translated by W. Crookes, F.R.S.

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RAGS (vol. iii. p. 691), Imports of. Of linen and cotton rags we imported in 1876—

	Tons	Value
From Russia	2,373	£30,146
" Germany . .	4,806	68,854
" Belgium . .	894	20,172
" France	2,150	40,674
" Spain	408	6,679
" Turkey	947	11,023
" Egypt	976	11,040
" other Countries . .	1,371	17,079
Total . . .	13,927	£220,972

Of pulp of rags, with some pulp of wood, we imported in 1876—

	Tons	Value
From Sweden	3,886	£39,178
" Norway . . .	9,198	90,901
" Germany	1,216	13,897
" Belgium . . .	332	3,418
" British India . . .	723	7,577
" other Countries . . .	1,208	12,473
Total . . .	16,027	£167,447

Of woollen rags (applicable to other uses than manure, torn up or not), we imported in 1876:—

	Tons	Value
From Denmark	1,527	£36,910
" Germany . . .	8,076	186,663
" Holland . . .	3,117	76,047
" Belgium . .	6,400	184,010
" France . . .	7,896	138,170
" Turkey . . .	467	8,010
" other Countries . . .	1,462	£27,314
Total . . .	28,847	£660,220

RAGS, EXPORTS OF. Of rags and other materials for making paper (except of woollen), we exported in 1876—

	Tons	Value
To France	519	£5,739
United States (Atlantic)	20,788	258,259
British North America .	507	6,409
other Countries . . .	1,175	7,962
Total . .	22,989	£278,469

RAISINS. (Vol. iii. p. 692.) The quantity of raisins imported in 1876 was as follows:—

	Cwt.	Value
From Spain	355,044	£654,275
" Italy	14,363	18,183
" Greece	13,352	17,415
" Turkey (Asiatic) .	196,571	361,910
" other Countries .	4,530	6,623
Total . .	583,860	£1,058,400

Currants—

	Cwt.	Value
From Greece . . .	1,116,948	£1,565,763
" other Countries . .	9,001	13,001
Total . .	1,125,949	£1,578,764

RAKU-WARE or **ERAKU-WARE.** A species of earthenware manufactured in Japan in the government of the Kiyoto families of Coreans. This ware resembles the Satsuma ware, but is paler in colour (*see* SATSUMA). The name is said to signify 'enjoyment,' but it appears that the name 'Eraku' is the name of a potter of Kiyoto, who first made it. It is a decorative porcelain with red ground, covered with ornaments in gold, generally mythological subjects. The clay for the Raku ware was originally brought from Shiraka, but it is now produced in several localities.

RATI. See ABRUS.

RED-COLOURED FIRES. See PYROTECHNY.

REFRIGERATION. (Vol. ii. p. 485, FREEZING.) In the article referred to the usual frigorific mixtures are given, and also some description of the ether and ammonia machines, which were first introduced at the International Exhibition of 1862, those of SIEBE, of HARRISON, of REECE, and of M. CARRÉ and Co., having especial notice. A little further attention is now required to this important question. The three principal forms of apparatus which are effective as refrigerators are the following:—

1. By the evaporation of ether by mechanical power. 2. By the evaporation of ammonia by heat, its condensation and re-evaporation by doing work. 3. By the mechanical compression and expansion of air or other gas.

The ether refrigerator, as already described (vol. ii.), consists of an engine to give the motive power to the various operations. To this engine is attached, on the same piston-rod, a vacuum pump. This pump has its suction pipe on the one side attached to the refrigerating vessel, which is partially filled with ether. By reason of the reduction of pressure in this vessel, produced by the pump, a portion of the ether evaporates. In evaporating, the ether renders latent a large quantity of heat, thus extracting it from the remainder of the ether, and producing a very low temperature. This reduction of temperature is made use of by circulating through the ether, in thin pipes, a fluid such as brine, or chloride of calcium, which will not freeze at 32° Fahr. This circulating medium is then made use of to freeze water in blocks for commercial purposes. The circulation is effected by means of a suitable pump. On the other side of the main vacuum pump, the volatilised ether is delivered at slight pressure into a pipe, circulating through a large tank, through which a constant stream of cold water is flowing. This causes the recondensation of the ether into a liquid, which then falls by gravitation back again into the main refrigerating vessel. Thus a constant circulation, without loss of the ether, is kept up; the heat abstracted in the refrigerator by evaporation on the suction side being carried off by the constant stream of cold water on the delivery side. This is the most usual form perhaps of refrigerating machines, and may be represented by the machines made by SIDDELEY and MACKAY, of Liverpool.

The economic action of the machinery very largely depends upon the perfection of

the vapour-pump, that a maximum suction draw, and a perfect and total delivery over of the volatilised vapour is truly effected in every stroke. To effect this requires intelligent and ingenious construction in the vapour-pump, valves, and valve-boxes. The contrast between the evaporating and compressing sides of the machine is most startling. The freezing chamber is lagged to prevent the absorption of heat, and upon the copper suction-pipe a white-frost rime will be formed by the exceedingly low temperature of the vaporised ether within. On the delivery side, however, the temperature is so high as to burn the hand when placed on the delivery box or pipe. And these startling differences of temperature are in the same material and within a foot of each other.

The arrangements of the freezing tank itself are almost as important for success as those of the engine or pumps.

The advantages of these machines are the clear blocks of ice produced by them. This effect is not easily attained, as, for the most part, artificial blocks are full of air-bubbles; but it has in this case been ensured by a constant agitation of the water whilst freezing, so that all the air-bubbles are driven out. This agitation is effected by a rocking beater or arm in each cell, which is operated upon by a band-driving wheel from the engine to a crank arm.

The partitions of the cells are made hollow, vertically, 1 or 2 in. thick, in which the non-freezing medium, viz., the brine, is made to circulate by suitable connections. The form of these intermediate divisions is so important that it has been made the subject of a patent. In the first instance they do not form a parallel space between each other; but the frozen block is smaller at the bottom than at the top, so that it draws with ease when released. In the second place it is important that the cells should entirely surround the freezing blocks, not only for the most effectual freezing, but principally that the release may be effected all round the block. The flat cells have each thus T-heads, like firebars, so as wholly to enclose the space between them. The release is effected by replacing the circulation of the freezing brine by a reverse circulation of brine at ordinary temperature. A little surface melting is thus effected over the whole block, and it readily draws away from the cells.

In the ammonia refrigerator machine an ammoniacal solution is placed in a boiler and heated in the ordinary way by a fire underneath. The ammonia is given off rapidly as a gas, and is collected at pressure in a coil of pipes placed in a tank, through which a constant stream of cold water runs. The ammonia is here liquefied, both by its own pressure and by the extraction of all heat above that of ordinary cold water. From this liquefied condition the ammonia will, on removal of the pressure, be changed at once into vapour. The liquefied ammonia is then used in a species of water engine or meter, which serves to pump back the re-united ammoniacal solution into the boiler again. The liquefied ammonia, after having here done its work, immediately on release flies into vapour; and this is conducted in circuitous tubes through the freezing tanks or chamber. By reason of this sudden re-evaporation of the ammonia, upon release from high pressure, a large quantity of heat is taken up and rendered latent, and this is of course abstracted from surrounding objects or from the liquid to be frozen. After having served its purpose, the ammonia is led into a chamber, meeting and mixing with the water from the boiler, out of which the ammonia has been evaporated. It is thus re-absorbed and then pumped—by the water-engine before referred to—back again into the boiler. The ammonia thus is continually circulating round—first evaporated by heat, giving the motive power to the arrangement; next becoming liquefied by virtue of its own pressure of from eight to ten atmospheres, and being cooled by a stream of running water, it then re-evaporates in doing work, thereby causing a large absorption of heat and effecting the freezing operation. It is lastly remixed with the unaërated water from the boiler, and is pumped back as a solution once again into the boiler.

Lastly, there is the simple, but still complex, mechanical machine, in which the atmosphere may be used as the medium by which freezing is effected. This depends on the following natural laws. When air is compressed, considerable increase of temperature is made sensible, exactly proportioned to the work done in compression. If now this heat be extracted when sensible, upon reduction of pressure and increase to normal volume, the air will be minus the amount of heat which has been abstracted from it by the water. In this way, by compression, cooling, and subsequent re-expansion, intense cold is produced by the use of compressed air, the cold of the exhaust air being intense. This production of cold is effected by a pump, alternately compressing and again allowing to expand a given quantity of air. When the air is compressed, and its heat is sensibly raised, its position in the machine is determined by a second non-conducting piston, which causes the air when hot and under compression, to be always on the one side, and when cold and expanded to be always on the other. Upon that side at which the heated air is always collected, is a hollow

cover, through which a constant stream of cold water is running in order to abstract the heat as it is rendered sensible. On the other side to which the expanded and cold air is driven, is another hollow chamber with large surface, through which is driven the brine or other solution whose temperature it is required to reduce below freezing point. The compressed air—always the same quantity, but rising in density as the cold increases—thus acts as a carrier of the heat from the liquid to be frozen to the constant stream of cold water which carries it away. Kirk's machine is, perhaps, the best example of this class of refrigerator.

We proceed to explain the various kinds of refrigerators which have been introduced.

Meidinger's *Simple Ice Producer.*—Dr. H. Meidinger has constructed a very simple machine founded on the observation that a concentrated solution of salt melts ice, producing a very low temperature. This machine consists of three parts; a cylindrical vessel (called *the cooler*), with double sides, quite open at the top; a conical tin vessel (called *the freezer*), about half the diameter of the former, reaching down nearly to its bottom, and furnished above with a firmly connected covering-plate, which rests on the top of the cylinder and fits it tightly like a lid; and, lastly, an annular strainer-like vessel (called *the salt-holder*), which is let down into the space between the cylinder and the freezer at about half the depth of the former.

The cylinder is charged about half full of pounded ice, upon which is poured a concentrated solution of salt; the strainer filled with salt is then let down, and lastly, the freezer containing the materials for the ice cream is forced in, and is in complete contact with the freezing mixture over its whole surface. The ice melts in the solution of salt, which, as it becomes diluted, dissolves more salt from the strainer, and thus remains newly saturated and capable of undiminished action upon the ice. The reduction of temperature throughout the apparatus is equable, and a mechanical movement of the vessel is not required.

M. Meidinger has drawn up a table from his own experiments, showing the production of cold by different mixtures, of which the following is an extract:—

Mixture	Fall of Temperature	Sp. Heat of Solution	Sp. Gr. of Solution	Loss of Heat Units for		Quantities to be used for 120° C. Heat Units		
				1 Kilo. of Mixture	1 Litre of Mixture	Salts	Water	Cost[1]
1 salt, 3 ice . . .	C. 21	0·63	1·18	125	100	Kilos. 1·5	Kilos. 1·5	0·24 to 0·12
3 sulphate of soda crystals, 1 concentrated hydrochloric acid	37	0·74	1·31	53	74	2·7	1·8	1·0 to 0·6
3 nitrate of ammonia, 1 sal ammoniac, 3 water	30	0·70	1·20	42	51	3·0	3·0	7·1 to 5·7
3 sal ammoniac, 9 saltpetre, 10 water .	28	0·76	1·16	40	46	3·1	4·3	2·6 to 2·2
3 sal ammoniac, 9 saltpetre, 4 sulphate of soda, 9 water . .	25	0·72	1·23	50	61	2·8	2·0	1·4 to 1·6

Berichte über die Entwickelung der Chemischen Industrie während des Letzten Jahrzehends.—Meidinger, *Bad. Gew.*

Rüdorff in 1869 published a table of results obtained by the solution of single salts, showing the fall of temperature obtained. Two salts named by him have not been previously mentioned; we therefore give them here:—

Sulphocyanide of ammonium—103 parts dissolved in 100 parts of water produces a fall of the thermometer of 31°·2.

Sulphocyanide of potassium—130 parts dissolved in 100 parts of water lower the temperature 34°·5.—*Berichte Chem. Ges.*, xi. 68.

The Generation of Cold by Evaporation.—The principle of the ether machine was patented in England by J. Perkins, of London, as early as 1834; and in 1856 John Harrison, of Geelong, in Victoria, patented another ether ice-machine. He states in his specification that he can, by means of his machine, produce a temperature of $-29°$, but

[1] The cost is given in decimals of a shilling, assuming the shilling to be approximately equal to the German 'mark,' which is really only of the sterling value of 11¾d. The cost wholesale and retail is given.

from an economical point of view he prefers $-2°$ to $-5°$. The process of freezing is then slower, but the expenditure of power is much less and the ice is transparent. In 1859 Lawrence established works at Liverpool for the production of artificial ice and sold it at one halfpenny per pound. In 1860 Landulay described an ether machine by T. Carré, of Paris (*Bull. Soc. d'Enc.*), in which the ether acted directly upon the water to be frozen. Carré abandoned this machine for his ammonia one. In 1862 Dr. Siebe patented an improved ice-machine, which was mainly the same as Harrison's.

The following remarks on the ammonia, ether, and sulphurous acid machines were communicated to *Iron*. It is such a correct examination of the whole question that we are glad to be allowed to transfer it to our pages:—

'Comparing the advantages of ammonia as a refrigerating agent over ether and sulphurous acid, the value of each depends upon the following three things:—1. On the temperature at which each becomes vaporised, for on that depends the quantity of fuel used in producing the cold, and also the lowness of temperature obtainable. This last is very important in making clear block ice, as a low temperature increases the rapidity of the operation, and therefore causes greater economy. 2. On the tension of their vapours at equal temperature, for on that depends the amount of expansion of which each is capable, and therefore the amount of cooling effect which an equal quantity of each is capable of producing. 3. On the latent heat of each, for on that depends the quantity of heat each is capable of absorbing by passing from the liquid to the gaseous state. The boiling point of each at the pressure of atmosphere is as follows:—

Ether	Sulphurous Acid	Ammonia
$+95°$ Fahr.	$+15°$ Fahr.	$-28°$ Fahr.

Ammonia has therefore the advantage of 123° of temperature over ether and 43° over sulphurous acid. The tension of the vapours of each at 100° Fahr. is—

Ether	Sulphurous Acid	Ammonia
35 in.	120 in.	450 in.

Here again ammonia is very far superior to either of the others. The latent heat of each in heat units is as follows:—

Ether	Sulphurous Acid	Ammonia
$162-8°$	(About) 172°	900°

Ammonia has therefore an advantage of more than 700 heat units over each of the others—that is, 1 lb. of ammonia vaporised will produce nearly six times the cooling effect of either the same quantity of ether or sulphurous acid. Besides what is stated above, ammonia has the following other advantages: its low boiling point allows it to vaporise at 28° Fahr. below zero without the necessity of removing the pressure of the atmosphere by large air-pumps, which are both likely to get out of order and are also very costly to work, on account of the power required to drive them. The recondensation of the ether and sulphurous acid gas has also to be performed by compressing the gas by air-pumps, whereas in the ammonia machine the gas is condensed by its own pressure—that is, by adding heat in one part of the machine and taking it out in the condenser. The sulphurous acid has the advantage over the ether machine by being able to obtain lower temperatures on account of its lower boiling point; but the ether machine has a great advantage over the sulphurous acid machine, inasmuch as the tension of its vapour at equal temperatures requires much less power to condense it again than the sulphurous acid. In the ammonia machine, as the gas is condensed by its own pressure and no steam power is used, it makes no difference. A very great advantage the ammonia has over the others is that the temperature of the condensing water does not affect the economy of working, as with very hot water it is only necessary to work it at slightly higher pressure. Hot water for condensing so increases the tension of the ether or sulphurous acid vapours that a great amount more power is required to condense them. The quantity of water used by the ammonia machine is very much less than the sulphurous acid machine, the latter requiring nearly four times as much. This is caused by the necessity of using cool water to condense the sulphurous acid gas, whereas with ammonia the water need not be run off till heated to 120° Fahr., or even more, without increasing the expense of working or decreasing the cooling power of the machine, which would be the case with the sulphurous acid. The ammonia machines are constructed entirely of iron, of which the ammonia acts as a preservative. The ammonia does not decompose when exposed to air, nor chemically combine with it in any way. In starting a machine the air is got rid of by getting up a slight pressure after the ammonia is put in,

which drives all the air out. In starting either an ether or sulphurous acid machine it is necessary to first obtain a vacuum in them, which is often very troublesome. If air comes in contact with the ether it decomposes, and the whole charge has to be thrown away. With the sulphurous acid the effect is even worse, as the sulphurous acid is turned into a liquid which violently attacks metals, and the machine would most likely be destroyed. As both these machines work with a vacuum, it is impossible to keep all air out. The pressure at which the ammonia machine is worked varies according to the temperature of the condensing water. With water at, say, 60° Fahr., it is about 105 lb.; at 85° about 140 to 150 lb. Ammonia machines are very simple to work, and as there are no moving parts except one small pump, which for an 8-ton machine is only 2 in. diameter and 6 in. stroke, and as they are always supplied in duplicate with each machine, there is no chance of a breakdown or stoppage, and no repairs are required. Ammonia is very cheap (about 3½*d.* per lb.), and as it is mixed with water, can be easily carried about, and the same charge may be used for any length of time. As there are no moving parts in the machine, the waste of ammonia is about *nil*. Both ether and sulphurous acid are expensive, difficult to obtain and to carry about (the latter especially, as the price is 2*s.* 6*d.* per lb.), and at 90° temperature it has 60 lb. pressure, so that in hot countries it is very dangerous, and has to be packed in strong copper vessels, whereas ammonia mixed with water is only put in glass bottles or thin sheet-iron drums. The cost of working the ammonia machine is taken from actual working, and not from theoretical calculation. The total cost is 63*l.* 12*s.* for working four 20-ton Reece's ice machines. The quantity of coal used is calculated by taking the quantity which four 20-ton machines would use if working independently, with high-pressure engines blowing their steam into the air; but if four machines were worked together by one or two condensing engines, a quarter of this coal might be saved. The coal is taken at 20*s.* per ton, but ought to be bought by contract for less than this. This quantity of coal includes power to pump water for condensing from the well. The waste of chemicals and oil waste and sundries are taken at extreme rates. The water might cost less than 1*s.* per 1,000 gallons.'

M. A. Terquem has put forth the following theory of freezing machines, which well deserves serious attention:—

Freezing machines are considered as heat engines reversed; their cycle of maximum effect, however, differs from that of Carnot in being comprised in three lines. M. Linde, of Munich, traces the cycle by means (1) of an isothermal line (A B), the heat being removed and the gas compressed at the higher temperature T^1; (2) a mixed line (B C) intermediate between an adiabatic and isothermal curve, the gas expanding in passing from T^1 to a lower temperature T^2, cooling a body in contact with it and always possessing the same temperature as the body; (3) an adiabatic curve which closes the cycle, according to which the gas is compressed, whilst the temperature becomes the initial temperature T^1. The equation of the mixed curve and the maximum effect of an air-freezing machine are given according to M. Linde. M. Armengaud has also obtained the same maximum effect; and the author shows that an infinite number of machines produce the same maximum effect, without reference to the fluid employed.—*Comptes Rendus de l'Académie des Sciences*, vol. lxxxiv. p. 902.

A refrigerating machine devised by M. P. Giffard is said to be capable of producing cold air at temperatures ranging from freezing point down to −39° Fahr., without the aid of chemical refrigeratives. Expansion of the air may be regulated, so that the temperature of the issuing air may range between 50° Fahr. and −22° Fahr. The machine consists chiefly of two cylinders placed vertically the one over the other, the lower being for compression, the upper for expansion. Both are provided with double-acting pistons, one rod passing through and working both. The covers of each cylinder are provided with admission and escape valves, and the compression cylinder is fitted at the top and bottom with pipes having rose ends, through which, by a small pump, jets of water are injected to cool the air under compression. From this cylinder the compressed air and its cooling water pass into a reservoir, from which the water is forced on to a cooling apparatus, whilst the compressed and cooled air is passed into the expansion cylinder and thence used. The cylinders are supported upon a bed plate, also carrying a pair of side frames provided with plummer blocks at the tops, forming bearings for the crank shaft from which the pistons receive their reciprocating motion. The crank shaft likewise carries small bevel pinions through which the valves of the expansion cylinder are worked at proper intervals, and gearing by which the pump, providing water for the compression cylinder, is worked.

The periphery of the pistons is provided with two parallel-sided grooves, the bottom of which is of a V form. Into the inner portion of the parallel part of these grooves

are sprung india-rubber rings of rectangular section, outside which are fitted leather rings of similar section. Small holes are made in either face of these pistons, communicating with the V-form cavity inside the india-rubber, into which the air enters at a variable pressure corresponding to the intensity of compression; the friction on the side of the leather ring being that due to the pressure at any part of the stroke, and the area of the internal diameter of the india-rubber ring; the co-efficient of friction between the leather ring and the cylinder having been ascertained to be equal to 0·10. The escape and admission valves have hard india-rubber faces; an annular groove is formed in one side of these india-rubber rings, into which the air under compression enters and dilates them.

The packing ring in the piston-rod stuffing-box is also of india-rubber, with an annular ring in the face towards the piston, the air entering which expands it internally and externally, causing it to fit the stuffing-box and the piston-rod in the manner of a common hydraulic press leather cup.—*Annales du Génie Civil*, vol. xiii. p. 773.

M. Tellier, of Paris, has used methylic ether in place of ethylic ether for the production of cold in his machine, which is constructed like Siebe's. Methylic ether is formed by the action of sulphuric acid upon wood spirit. It is gaseous at ordinary temperatures and pressure, and can be condensed to a liquid only by great pressure or extreme cold. The liquid at the pressure of our atmosphere boils at $-21°$.

Other substances of low boiling points may be employed for producing a decrease of temperature, but no advance can be predicted theoretically from their action.

Van der Weyde, of New York, makes use of chymogen, a constituent of natural petroleum, evaporating between 0° and 16° C., which costs in the United States 1½d. English per gallon (*Deutsche Industrie*, 1869, p. 130). Liénard and Hugon, of Paris, are reported to use sulphide of carbon.

The Glaciarium.—One of the most striking examples of the successful application of the methods for freezing water (already described) is to be found in the construction of real ice rinks in Chelsea, and on board the floating bath on the Thames. The following statement of the scientific principles involved in the production of these ice floors is chiefly copied from an excellent article by the constructor, Mr. Gamgee, which appeared some time since in *The Engineer*—the scientific articles in which journal are always of the highest class—and we have not met with any description elsewhere of so thoroughly satisfactory a character:—

'Upon a small scale and in what may be termed "bulk," the artificial production of ice does not present to the chemist or manufacturer any very great difficulty. But the question assumes a different aspect when the result of artificial congelation is to take the form of an extended surface, in which thickness is enormously disproportionate to the other dimensions. The maintenance, moreover, of this frozen floor, which has also to sustain a considerable amount of pressure at a constant temperature, or, at least, at a temperature sufficiently low to prevent the surface becoming unfit for skating purposes, is not the least arduous part of the operation.'

The author of the article then proceeds to remark that—

'Any substance in passing from one state to another, from the solid to the liquid, from the liquid to the gaseous, or inversely, absorbs or sets free, renders latent or sensible, a certain portion of caloric, or number of units of heat. A very simple method might, in accordance with this law, be devised for changing the state of any substance. All that is necessary would be to take two substances, and change their state inversely, so that the heat set free by one should be absorbed by the other. There are, nevertheless, some substances which have hitherto resisted all attempts to make them change their state. But nothing is simpler than this method theoretically, and the practical difficulties attending its execution, as will be seen, have been successfully overcome. Let us suppose that we have a given weight of any liquid at a given temperature T, and while at this temperature it changes its state to that of a gas. In its transition it absorbs, or renders latent, a certain number of units of heat N, which may be called the latent heat of volatilisation. The temperature remains constant during the change of state, and the elastic tension P also, but the volume does not. If different liquids be taken, and be caused to pass into the gaseous condition at the same temperature T, different values will be found for N, P, and V, and the difference in many instances will be very considerable. In order to place the question in a definite form, let a quantity of any volatile liquid be placed in a reservoir A, and let the vapour which forms be pumped at a temperature T and pressure P into another reservoir B, where it assumes a temperature T^1 and a pressure or tension P^1; the liquid passes into the gaseous state in A, and then returns to its liquid state in B. If, now, communication be established between B and A, the liquid will then flow back again into A, and resume its original temperature and pressure, and the circulation will be complete. It is necessary to this result that

$T^1 > T$, and also $P^1 > P$. This represents the conditions to which the freezing agent is subjected in the glaciarium to which we shall draw attention.

'From these data may be deduced two equations, from one of which can be calculated the work in foot-pounds done by the pump in effecting the compression of the vapour from the temperature T to T^1; from the other the number of units absorbed in the change of state in the reservoir or refrigerator A*. Put F = work done by pump; $\frac{1}{a}$ = co-efficient of expansion of gases; S = specific heat of the liquid; d the density of the vapour at 32°, taking air as the standard; L the latent heat of the liquid at temperature T; and W and W^1 the weight of a cubic foot of air and the atmospheric pressure per square foot respectively, and the rest of the notation as above. Making the calculation for 1 lb. of the liquid, and assuming the laws of MARIOTTE and GAY-LUSSAC to hold good, we have $F = \frac{W^1(a+T)K}{W d \times a}$, in which equation K is the Napierian logarithm of the quotient of the two pressures $\frac{P^1}{P}$. The value of $\frac{1}{a} = \frac{1}{460}$; W = 0·08; and W^1 = 2116. If N equal, as before, the number of units of heat absorbed in the refrigerator A, the equation is $N = L - S(T^1 - T)$. In order to establish the relationship between the work done and the heat absorbed, these two equations must be combined. If a quantity of heat, or number of units N, can be utilised at temperature T and T^1, a certain portion of them may be converted into work, represented by the fraction $N\frac{T^1 - T}{a+T}$. In the arrangement of the refrigerator and condenser N = L at temperature T in the latter. Putting M for the mechanical equivalent of heat, and F^1 as before, we obtain $F^1 = L\frac{T^1 - T}{a+T} \times E$. The total number of units of heat absorbed in the refrigerator $A = N = L - S(T^1 - T)$, from which $F^1 \frac{[L - S(T^1 - T)]M(T^1 - T)}{a+T}$ equals the work done in subtracting a quantity of heat at a temperature T, and raising it to T^1. Equating this formula with that obtained for work done, we have

$$\frac{W^1(a+T)K}{W d \times a} = \frac{[L - S(T^1 - T)]M(T^1 - T)}{a+T}$$

from which may be deduced the general formula given by M. PICTET,

$$L - S(T^1 - T) = \frac{W^1(a+T)^2 K}{W d \times LM \times a(T^1 - T)}.$$

'The three essential characteristics of a glaciarium, independently of the mechanical power, are the fluid frozen, the freezing medium, and the freezing agent. The existence of the second of these is rendered necessary by the impracticability of bringing the freezing agent into direct contact with the fluid to be frozen. The first of these in the Chelsea glaciarium is water, the second a solution of glycerine, and the third sulphurous acid. This last has generally been regarded as a gas, although condensible into a liquid under the pressure of one atmosphere at a temperature of zero C. It may be readily prepared on a small scale by heating oil of vitriol with copper clippings, when the following reaction takes place:—

$$2(HO\ SO^3) + Cu = SO^2 + Cu\ OSO^3 + 2\ HO.$$

It has a specific gravity of 2·21, and a hundred cubic inches weigh 68·69 grains. As a liquid, taking water as the standard, its specific gravity is 1·45. For the purposes of the glaciarium at Chelsea, the sulphurous acid was obtained in a liquid state by Mr. GAMGEE, from Switzerland, in strong copper bottles of the shape of a sausage, containing about a couple of hundredweights. At a temperature of 14° Fahr. the condensed liquid is in a normal condition, and exerts no pressure. The bottle of acid is placed upon a small truck carrying scales, and a given weight run off into the lower part of the condenser by the pipe. The condenser is filled with water at the ordinary temperature, supplied direct from the main, and has a system of double pipes, inclosing an annular space, well known as "GAMGEE's compound tubular arrangement." The smaller, or internal, tubes have a diameter of ⅝in., and the larger, or external, of 1 in. The water passes through the smaller tubes, and arrives at the bottom of the condenser by the pipes curved upwards at the ends, and shown in the drawing. It then rises through the condenser and passes out by the overflow pipe. The water is continually flowing in this manner, and has therefore a perfect circulation. The sulphurous acid, still in the liquid state, flows out of the bottle into the lower part of

the tubes in the condenser. The cock is opened, and the liquid acid expands into the gaseous state in the refrigerator. The cock is necessary to allow the connection to be cut off between the condenser and the refrigerator if required. Upon entering the refrigerator, the sulphurous acid expands into three hundred times its original volume. The arrangement of the tubes in the refrigerator consists of a number of small tubes inside a large one. The sulphurous acid, now in the gaseous condition, rises up the large tubes into the upper part of the refrigerator, where the tubes are fixed. Every pound weight of sulphurous acid passed through the pipe absorbs 170 English units of heat.

'A double-acting pump of the ordinary construction now comes into operation. A vacuum equal to about 2 in. of mercury is produced, and partly by its means, and partly by its own elastic pressure, the sulphurous acid rises in the pipe, which is always at a very low temperature, and is then forced through into the condenser. The gauge shows a pressure of about one and a half atmospheres, which is sufficient, with the assistance of the water, to effect the recondensation of the gas. When the recondensed liquid—which commences to change its former gaseous state directly it enters the pipe—enters the condenser, it passes into the box into which the double tubes are fitted, and flows through the annular spaces between one-half of the tubes as far as a stop. It then passes through the remaining half all together, and finds its way to the bottom of the condenser, and thence back into the refrigerator, thus establishing a perfect circulation. The temperature of the sulphurous acid varies from 21° to 11° Fahr. It may be noticed with regard to the pump that the valves were found, when made of the ordinary gun-metal, to give out. They have since been made of bright "Bristol brass," with spindles of cast steel screwed and soldered in, and have been found to give complete satisfaction. The sulphurous acid does not in any manner corrode the machinery, and this great advantage is due to the fact that it never comes in contact with the atmosphere.

'Mr. Gamgee has become aware that the usual vacuum machines consume unavoidably too much fuel, and are too wasteful and expensive for glaciaria and the manufacture of ice in blocks. Mr. Gamgee was conducting experiments on the uses of compressed gases, when he was induced by M. Raoul Pictet, of Geneva, to convert his ether machine into a sulphurous acid one. One of M. Pictet's improved machines was used on the premises at Chelsea.

'The freezing medium,—which we may now consider,—is an aqueous solution of brown glycerine, stored in underground tanks. It has, as will be readily understood, a very low freezing point. A solution of glycerine and water, made in equal proportions, is practically incapable of being frozen. The proportions used at Chelsea are four parts of glycerine to six parts of water, and the mixture freezes at zero Fahr. It is first of all pumped into a copper box, fixed in the upper part of the refrigerator, to be cooled down to the requisite temperature. It runs down the inner tubes of the refrigerator which are fixed in the box, being surrounded by the sulphurous acid, which fills the large tubes as already mentioned. It then reaches a cast-iron box at the bottom of the refrigerator, into which it is distributed by a series of radial tubes. Being now sufficiently cooled, it is pumped carefully and without violence into a wooden tank, placed some 10 ft. above the ground, from which it flows by simple gravitation into the main pipes supplying the glaciarium itself. There are two main pipes connected with the outlet and inlet pipes respectively by junction pipes, one of which is ¾ in. diameter, and the other 2 in. The upper pipe is slightly contracted at the junction. The main pipes are circular in section, and have each a diameter of 6 in. They are placed the one vertically over the other at right angles to the small pipes, which are laid longitudinally in the ice floor of the glaciarium. These small pipes are of copper and oval in section, the major axes being 2½ in. in length and the minor ⅝ in. The space between them varies from ⅜ in. to ½ in. They may be said to be laid in pairs, one being connected with the upper main and the other with the lower. The free extremities are connected together by a bent pipe or loop, so that one of the pair acts as a flow and the other as the return pipe. The solution of glycerine flows forwards in every one of these separate pairs, and returns by the other pipe to the outlet pipes, by which it is conducted to the refrigerator, cooled down again, pumped into the elevated tank, to resume once more its course of circulation. During the whole of the circuit the temperature varies to the extent only of a few degrees.

'The frozen floor of the glaciarium presents some points of difference with respect to naturally frozen ice. Being directly supported by concrete joists and planking, the ice is of a more solid character, and neither bends nor cracks under the skaters. As it is also frozen at a very low temperature, it is harder than ordinary ice, and possibly may have a higher specific gravity. If we take the thickness of the ice in the glaciarium at Chelsea, on an average, at 1¾ in., the whole floor would represent, *en masse*, a solid block 5 ft. cube.

'As a matter of fact, the ice in the glaciarium does not "cut up" so freely as ice naturally frozen, but still when skated upon, it inevitably must do so to a certain extent. The best method for insuring a minimum of cutting up, lies in the employment of proper skates, or rather in the kind of skates which are best adapted for the glaciarium. It must be borne in mind that every shred of ice cut up represents so much money. However large glaciaria may in future be made, they will always be of comparatively a limited size. Consequently the description of skating for which they are more particularly suited is "figure" skating. A glaciarium is to a naturally frozen large pond or lake what a well-ordered, well-kept park is to a common. The individual who rushes about at a rate of fourteen miles an hour with skates which have blades 15 in. in length is not a suitable or desirable visitor to a glaciarium. The description of skate best adapted for the place is what might be termed a drawing-room skate, and should be of the following pattern:—The sole piece should be of wood, and the blade the exact length of the foot, or, rather, of the boot, turned up neatly at both ends, without the slightest bit of superfluous metal in it. In fact, except for ladies and children who are beginners and light weights, any skate, the blade of which is sharp at the heel, should be tabooed in a glaciarium. The depth of the blade should be sufficient just to prevent the wood from grazing the ice when cutting the edges. In a word, the whole skate should be as small, light, neat and compact, as is consistent with the size of the wearer's foot. Large-bladed skates are not only not required, but exceedingly detrimental to the ice, and all such barbarous inventions as iron skates, with their high and destructive leverage, and useless amount of extra and injurious metal, should be prohibited on the floor of a glaciarium. If it is considered necessary to maintain stringent regulations with respect to the description of roller skates permitted in the rinks, how much more is a similar precaution needed with regard to glaciaria? Another point to be kept in mind when skating on ice thus formed is that, owing to its superior hardness, the blades of the skates must be in excellent order. When the blades want grinding or setting, they will not "bite." The consequence is that in making a stroke they slip, and shred away the ice very considerably. Skates, in first-rate order, damage the ice but very little. We are convinced that the proprietors of future glaciaria will find it necessary to pay very great attention to the description and quality of skate used on their premises.'

Carbonic Acid has been repeatedly proposed as an agent for the production of cold. By employing solid carbonic acid the most intense cold known can be produced. The enormous pressure required to solidify the gas is such that it is under all circumstances attended with some danger. For the necessities of science solid carbonic acid has been frequently used, but for practical purposes we have not yet the means for employing it with economy and safety.

Sulphuric Acid.—Machines for the use of sulphuric acid have been made by Erum. and Lessmeister, of Cologne, but these machines are open to the objections already referred to in relation to carbonic acid.

We give some account of one of the *aqua ammonia ice-making machines* which are manufactured by Oscar Kropff, and are to be obtained from Sladden, Brothers, and Company, Queen Victoria Street, London:—

The boiler required to work the machine is built in brickwork. This is half filled with a strong solution of ammonia, which is caused to evaporate by the application of heat, thus forming gas, which is conducted to the square elevated tank, where it enters a condenser (worm-pipe) submerged in cold water. The gas in its passage through this pipe becomes cool. Through constant heating and separating the gas in the condenser begins to attain a strong pressure, which again, through cooling in cold water, condenses and passes as a fluid into the small cylinder under the tank. Here as a fluid it remains under pressure, as without pressure it would again evaporate into gas, and through a glass gauge the fluid can be observed by the manager. If the cylinder be full the fluid will rise through the narrow pipe to the right and thus indicate its presence. From the cylinder or gas-holder the gas is conducted by a pipe to the valve on the top of the large ice box, which is in connection with the worm-pipe inside. At the commencement of the operation this valve is kept closed; but as soon as the gas has attained a pressure of eight to ten atmospheres it is slightly opened. The gas then in its passage through the worm-pipe of the condenser (which is always surrounded with cold water) is condensed, and the solution passes through the valve to the worm-pipe in the large square ice-box to the right, where it again commences to evaporate, extracting at the same time heat from the solution of chloride of calcium in which the worm-pipe in the ice box is submerged. This extraction of heat so lowers the temperature of the solution of chloride of calcium as to render it capable of turning the fresh water, contained in the ice cases, to ice. The ammonia, which has been turned to gas again in the pipes in the ice-box to the right, rises through the thick long pipe and passes to the absorption cylinder in the centre, and

at the same time the weak solution of ammonia, which has lost the gas by heat, passes out of the boiler by the pipe on its right side into the exchanger under the cylinder just mentioned, from thence it proceeds to the cooler, the lower cylinder to the right, under the tank, to the absorption cylinder, where it absorbs the gas coming from the ice-box, and from these cylinders it is pumped back by the pump under the centre (seen in the opening under the elevated absorption cylinder) into the boiler to be again heated. When the machine is working the valve on the ice-box must be opened just sufficiently to allow the gas to escape, but not to allow the pressure to fall, and the valve between the cooler and the absorption cylinder must be so regulated as to admit the proper quantity of the weak solution from the boiler as will absorb the gas from the ice-box.

A machine for making 200 lb. of ice per hour requires a two-horse engine to drive it.

The investment and running expenses for the management of a continuous ice-machine of 500 lb. hourly capacity will be:—

	£	s.	d.
Price of machine	900	0	0
Steam-engine (three horse-power)	127	10	0
Water-pump	27	0	0
Belting and transmission	31	10	0
Cost of mounting	24	0	0
Investment	£1,110	0	0
Interest on 1,110*l.* at 5 per cent.	55	10	0
Annihilation on 1,110*l.* at 10 per cent.	111	0	0
Yearly interest	£166	10	0

Reckoned at 300 working days per year would be about 11*s.* per day.

Daily Expenses of Twenty-four Hours.

	£	s.	d.
Interest	0	11	0
Three attendants	0	8	0
One machinist	0	5	0
Coals	0	9	0
Chloride of calcium	0	0	9
Aqua ammonia	0	6	9
Oil and light	0	1	6
	£2	2	0

Production of Cold by Expansion.—If a gas is compressed the mechanical power applied is converted into heat and the temperature rises. If a hot compressed gas is allowed to re-expand, always under full pressure, the heat is transformed into mechanical power, and a fall of temperature issues in the same measure as the rise during its compression. If a hot and compressed gas is cooled down and then expanded, it falls below the initial temperature, and very great degrees of cold can be attained. Thus air at 2, 3, or 4 atmospheres cooled down to 30 C., and allowed to expand 1 atmosphere, yields respectively the temperatures of $-25°$, $-53°$, and $-73°$ C.

Sir John Herschel many years since proposed to sink a Cornish boiler in the ground, to place in it the water to be frozen, then to pump air into it and compress it, allow it to remain over night to be cooled down, then, liberating the compressed air in the morning, the water in the boiler is frozen by the cold produced on the expansion of the air.

Linde has given a treatise on 'the withdrawal of heat at low temperature by mechanical agencies.' The main result at which he has arrived in the way of calculation is, that for the economical working of ice machines the temperature of the body used as a medium during expansion must not be lower, and during compression not higher than is absolutely necessary. Linde proves by calculation that in a theoretically perfect machine, which produces ice at $-3°$ from water at $+10°$ C., 1 kilo. of coal should yield 100 kilos. of ice.—Bayer, *Industrie u. Gewerbeblatt.*

Armengaud communicated to the *Académie des Sciences* certain theoretical speculations on air machines. He laid great stress upon the importance of cooling the air during compression by means of water. The difficulty of effecting this by means of water injected in the moment of compression he overcame by introducing into the air, as drawn in, water by means of Giffard's injector in fine spray. According to his experiments it is most advantageous to work with a degree of expansion $=2$, in case the power exerted, in proportion to the cold produced, is only half as great as when the refrigeration is carried on during compression as if executed previously.—*Comptes Rendus*, lxxxvi.; Dingl. *Polyt. Jour.*, ccviii.

Several varieties of these machines are manufactured upon the principles above described. They are not only made for the manufacturer, but, on a small scale, for the use of the household, and even for the production of ice on the table. A full account of all these machines was given in the *British Mail* of January 1, 1877.

Ice Consumed.—In 1876 we imported:—

	Tons	Value
From Norway	184,021	£167,092
" other countries	10	15
	184,031	£167,107

The following statement of the quantities of ice used is from the paper already referred to by Dr. H. Meidinger, and published in the report by Dr. A. W. Hofmann, *On the Development of the Chemical Arts during the last Ten Years*:—

'In 1866 the quantity of ice consumed in New York amounted to 250,000 tons, or 5 cwt. per head. (In 1877 I expect an enormous advance upon this has been made, the practice of drinking iced water having, from being a fashion, become almost a disease.) The weight of ice stored up was 543,000 tons, while the capital employed in the trade amounted to $2,260,000, the wholesale price being about 1*s*. for the cwt.

'In 1871 the North German Ice Works stored up 600,000 cwt. of ice and delivered it to subscribers at 77 pfennigs per cwt. (100 pfennigs are contained in the German mark, which is of the value of 1*s*. 0½*d*. sterling).

'In 1869, in Dreher's brewery at Klein Schwechat, near Vienna, there were used 28,874,219 kilos. of ice; in the following year the quantity was raised to 31,531,924 kilos.'

There are now in this country several establishments for the manufacture of ice, especially in the chief fishing towns on the coast, nearly all the fish being packed in ice.

Ice Formation by Natural Cold.—A company has been formed for obtaining natural ice. This company holds a grant from the Duchy of Cornwall, and on the northern edge of Dartmoor they have constructed several shallow ponds, which they fill with very pure water. At an elevation of above 1,000 feet the ice is formed early in the year, and is continued long into the spring. As a film of ice is formed it is taken off and stored. In conclusion, it will be interesting to notice more fully this experiment which is being made by Mr. James Henderson, of Truro. Several large and shallow ponds have been constructed upon the heights of the Moor; these are filled with the purest of water from the granite, and when the temperature falls below 32° Fahr. a coating of ice is produced. Ice of 6 inches thick of splendid quality has been thus formed. This crust of ice is removed and stored, for the use, during the summer, of the fisheries, and any other purposes of luxury or utility for which ice is now become a necessity.

The works at Dosmary Pool, in Cornwall, are more interesting, because there Mr. Henderson has fixed an hydraulic press, worked by a steam-engine, for compressing the ice into blocks, with a pressure of nearly 200 tons. He has taken out a patent for this machinery. The method of proceding will be this. They take off the ice from the pool, which is 40 acres in extent, as soon as it attains 2 inches in thickness or thereabouts. The ice will then be stored and rammed with rammers in the store; it will thus freeze into a solid mass. When it is to be sent away it will be cut out in smaller sizes, crushed, and pressed in the hydraulic press into blocks of about 1 cwt. in each block.

This extreme pressure forces all the air out of the ice, rendering it very much more durable than a naturally frozen ice. It will bear any amount of rough handling—indeed, it is very difficult to break it, and when heavy hammers are used it becomes bruised, like loaf sugar or marble, rather than fly into fragments.

This is regarded as the most valuable part of the discovery, and, Mr. Henderson thinks, will be of immense use in our fisheries, where such enormous quantities of ice are required every season.

We can, by use of this process, avail ourselves of the ice naturally frozen at our own doors, without going to Norway or to North America for our supply.

Mr. Henderson has made some very interesting experiments with pressing ice. The pressing season will commence about March next, 1878.

During the operation of pressing a large quantity of water exudes from the ice, although very dry, apparently, when first put into the box. The block turns out like a block of marble, slightly opaque at first, but on being kept a week or two it becomes quite transparent. The opaqueness arises from the crushing of the ice into fine particles, and the subsequent transparency from the extreme cold produced by the expansion, the regelation of the mass after being relieved from the pressure.

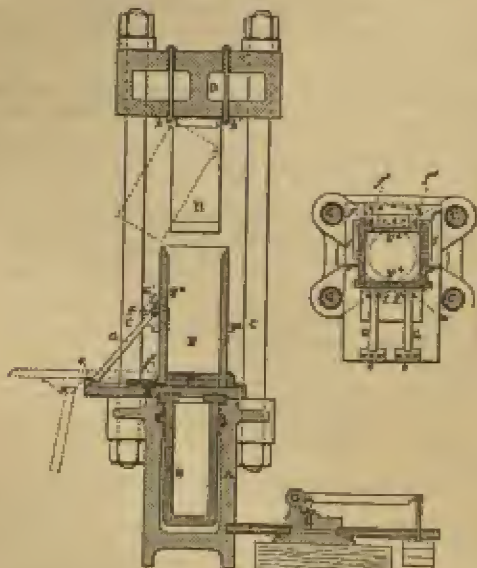
The following is Henderson's improvements in compressing ice and snow as specified, September 27, 1877:—

'My invention relates to the manufacture from thin sheets or fragments of ice or from snow of blocks or slabs of large size by compression.

'By compressing fragments or thin sheets of ice with sufficient force in a box or other confined space, they will be made to cohere and form a solid block or slab of ice, and similarly when snow is compressed. And my invention consists in certain improvements in machinery, and the employment thereof for the manufacture, on a commercial scale, of small pieces of ice or snow into large blocks by compression. The ice or snow to be formed into blocks is placed in a box, constructed as hereafter described, and sufficient pressure is then applied thereto and continued until the fragments are consolidated into a compact block.

'The ice, in consequence of the pressure brought to bear upon it, gives up some of its latent heat to the liquid water which is present in the cavities between its particles, and which is expelled by the pressure, and the ice consequently becomes more dense

2471



2472

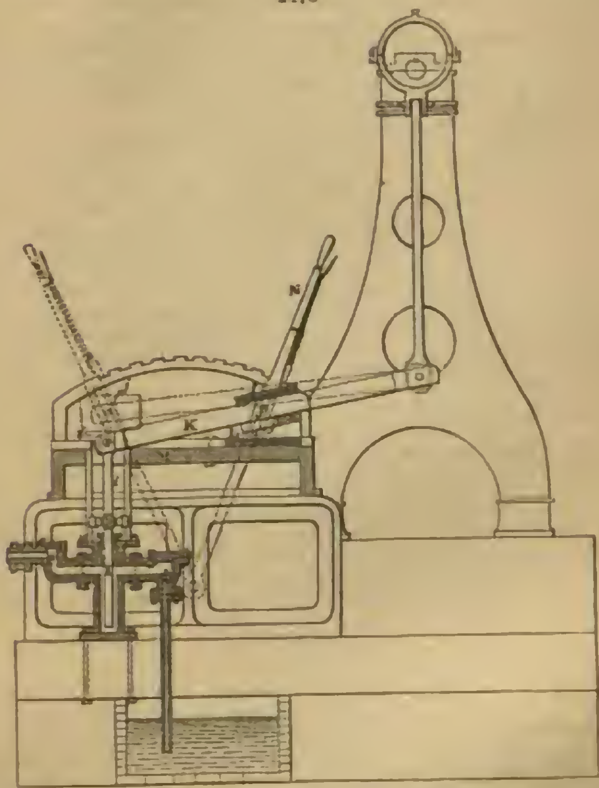
and of greater specific gravity; and on the pressure being removed from it, a certain amount only of the sensible heat is again absorbed and rendered latent, thus rendering the ice colder than before pressure.

'The machinery is illustrated in *fig.* 2471, which represents a vertical section of an hydraulic press, provided with appliances for compressing ice or snow into blocks; *fig.* 2472, a plan of the same with the press head and plunger removed; *fig.* 2473, a vertical section of the force pumps; *fig.* 2474, an end view of the gear connected therewith, and *fig.* 2475, a side elevation of a slightly modified arrangement of the said gear.

'The construction of the hydraulic press shown in *fig.* 2472 is much the same as usual, so far as the cylinder, A, ram, B, pillars, C, and head, D, are concerned; but the construction of the box in which the compression is effected, and the arrangement of the plunger, are novel, and are as follows:—E is a wrought-iron table or "follower" resting on the ram, B, and moving therewith. Upon this table is placed the box, F, in which the ice or snow is compressed, and to the under side of the head or cap of the press there is attached a plunger, H, corresponding to the interior of the box, F, so that as the latter is raised by the ram the plunger will enter the box and compress the ice or snow therein. This box, F, is constructed of wrought-iron, with a removable front and sides to facilitate the removal of the compressed block. The bottom or

bed, F^1, of the box rests upon, but is not necessarily fixed down to, the table or "follower," E, of the press; but it is desirable that the table, E, should be so fitted on the ram, B, and the bed or bottom, F^1, on the table, E, by parts of the one entering recesses in the other, as to always ensure the proper correspondence of the box with the plunger. The back plate, F^3, of the box is securely bolted or fixed to the bed, F^1, by a metal band passing behind the back plate and round the sides of the bed, or by clamps, or the plate may be made in one piece with the bed. The sides, F^2, of the box are connected with the back, F^3, by strong corner irons or clamps, f, which lock with cheeks or lugs, f^1, on the rear edges of the back plate to sustain the sides under pressure, and are hinged at f^2 to the back of said plate, to enable the sides, F^2, to be thrown back clear of the compressed block for the purpose of removing the latter.

2478



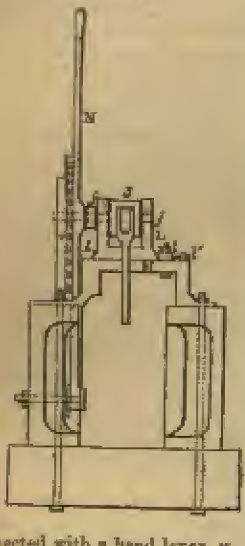
The front plate, F^4, of the box is received in a groove in the bottom plate, F^1, and is retained by a toe or dovetail, f^3, therein, on which it works as a hinge, falling down to a horizontal position level with the bottom, F^1, as shown in dotted lines, to facilitate the removal of the compressed block. The front plate is maintained in the raised position by one or more stay bars, G, having at their upper ends a firm abutment against the plate, as shown at G^1, and simply hinged thereto at g to keep them in place when the plate is lowered. The lower end of these stay bars abut against stops, e, securely fastened to the table, E. By this arrangement great strength and rigidity of the ice box under pressure are ensured, and the box may be readily opened to remove the compressed block.

' Instead of the stay bars, corner irons or clamps may be used, if preferred, received in staples on the sides of the box, and locked together by any suitable means. This plunger, H, of metal, or of wood shod with metal, is placed immediately above the ice box, and is hinged at one side, h, to the press head and secured thereto at the other side by a staple and removable pin, h^1, or other fastening, so that on releasing the

latter the plunger will hang in the position indicated in dotted lines, and so be out of the way, leaving the open-top of the ice box, F, entirely clear when filling or inspecting the box.

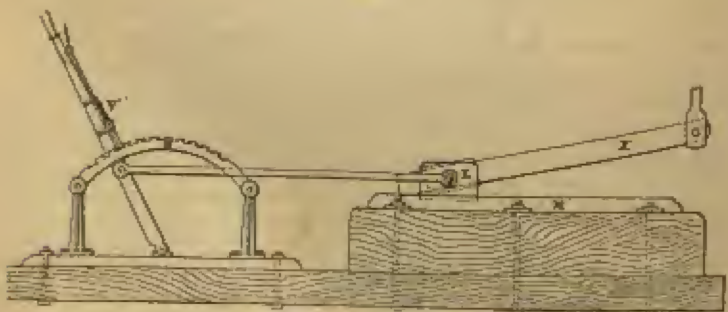
'It is desirable that the engine or motor working the pumps should not be stopped whilst removing the blocks of compressed ice and refilling the box; but as it is necessary to stop the pumps of the hydraulic press during these operations, motion is communicated from the engine or other driving shaft to the pumps through the medium of a lever, having a sliding fulcrum which may be gradually moved to any point of the lever, to regulate the stroke of the pump according to the power required, so that the latter may thus be gradually increased as the block becomes more dense, until the requisite power for the final pressure is attained; or the fulcrum of the lever may be made to coincide with the centre, by which the connecting rod of the pump is jointed to the lever, in which position no motion will be communicated to the pump, although the lever may continue to be worked by the motor.

2474



'The arrangement is illustrated in *figs.* 2473 and 2474. The pump, I, is of the ordinary kind used for hydraulic presses. The pump plunger is worked from a crank or eccentric on a shaft, or directly from the engine through a lever, K, connected at one end with the said crank, eccentric, or motor, and at the other end with the pump plunger by a connecting rod, i. J is a box, to the sides of which are fixed the pivots, j, on which the lever, K, oscillates. It is furnished with anti-friction linings at top and bottom, and is fitted to slide freely along the lever, K. The pivots, j, are supported in a movable bearing block or carrier, L, fitted to slide in dovetail guides or ways, l, on a bed-plate, M, the said guides being made adjustable by set screws, l^1. This carrier, L, is connected with a hand lever, N, by an extension of one of the pivots, j, or by a pin on the carrier received in a slot, n, in said lever. The latter is provided with a locking bolt engaging with a quadrant rack, O. By shifting the hand lever, N, the carrier, L, is traversed along the guides, carrying with it the box, J, and pivots, j, which may thus be placed at any point of the lever, K. The under side of the sliding-box, J, is not continued from end to end, but extends about one-third the distance only, as shown, to allow the box to pass the fork at the upper end of the pump connecting rod, i, sufficiently to bring the two centres, namely, the pivots, j, and

2473



the joint, i^1, in the same axial line, as shown by the dotted position in *fig.* 2473. To admit of this the end of the lever, K, which enters the fork of the connecting rod, i, is reduced in width, so that the width of the fork across from one side to the other, and the length of the pin of the joint, i^1, coincide with the width of the lever, K, and do not project in the way of the slide box, J.

'It will be seen that when the hand lever, N, is in the right-hand position the pump

is worked its full stroke, which is gradually decreased as the hand lever is moved over to the left, until it is in the dotted position, when no motion whatever is given to the pump, although the rise and fall of the right-hand end of the lever, K, is continued as before. In *fig.* 2475 the hand lever, N, and quadrant, O, are shown fixed on a separate bed in front of the pump, the carrier, L, being in this case actuated through a forked connecting rod jointed to the lever at one end, the forked end of the connecting rod spanning and working on the ends of the two pivots, *p*, that pass through the carrier, L. This carrier may also be made to slide along its bed by the rise of the hydraulic ram, A, by means of a rack and pinion and screw attachments, whereby the power of the pump will be automatically increased in the ratio as the pressure is required on the block of ice or other material under operation. It will be obvious that this lever with a sliding fulcrum may be similarly adapted with equal facility and advantage to the pumps of hydraulic presses generally, for pressing all kinds of materials.'

REICHHARDITE. This is the name given to a new mineral found in the upper stratum of the Carnallite (a salt more soluble than common salt), found in the salt works at Stassfurt, in Prussia. Its specific gravity in alcohol was found to be 1·61, in ether 1·71, and in benzine 1·68, while the specific gravity of ordinary sulphate of magnesia is 1·751. It occurs in amorphous masses. Its composition is similar to ordinary sulphate of magnesia:—

$$MgSO^4 7H^2O.$$

RESORCINE. To prepare resorcine benzine is acted upon by sulphuric acid, so as to substitute two equivalents of hydrogen by two equivalents of sulphuric acid: to effect this the benzine in vapour is passed into four times its weight of sulphuric acid heated to 464° Fahr. The new compound remains dissolved in the excess of sulphuric acid, which is mixed with about ten times its bulk of water and then saturated with lime. The sulphate of lime precipitates and the bisulphobenzylate of lime remains in solution. The latter salt is now decomposed by addition of carbonate of soda, which is added as long as a precipitate is produced. The resulting products are carbonate of lime and bisulphobenzylate of soda. The solution is filtered and the clear liquid evaporated to dryness, in order to obtain the soda salt, which is white. To convert this salt into resorcine the two equivalents of sulphuric acid should be removed and replaced by two equivalents of hydroxyle. To do this, treat the salt at a temperature of 480° with five times its weight of caustic soda. This is done in cast-iron pots, with mechanical agitators, heated in a bath of oil, the operation lasting from 24 to 30 hours. The melted stuff, when the operation is complete, is poured upon cast-iron plates, and when cool it is broken into small pieces. It is dissolved in water, the excess of alkali neutralised by sulphuric acid; the sulphate of soda is crystallised out, and the resorcin is left in solution. It is best removed from this by agitation with sulphuric ether, the ether being afterwards distilled off.—M. LOUIS DURAND, *Moniteur Scientifique*, vi.

Resorcin may be formed by the dry distillation of brazilin. The wash and mother-waters obtained in the manufacture of brazilin from Brazil-wood extract is mixed with chalk evaporated to dryness, and the residuum subjected to dry distillation.—See WATTS's *Dictionary of Chemistry*, 2nd Supplement, for RESORCIN AND ITS DERIVATIVES.

M. R. WAGNER says, if to an aqueous solution of resorcin sulphate of copper is added, and then ammonia enough to redissolve the precipitate, a deep black liquid is obtained which dyes wool and silk black.—*Bulletin de la Société Chimique de Paris*, May 1876.

An ether of resorcin is formed by heating resorcin with hydrochloric acid under pressure. It is a scarlet powder, which, when rubbed, assumes a beetle-green lustre. It consists of $C^{24}H^{18}O^3$.—L. BARTH, *Deut. Chem. Ges. Ber.* ix.

RETINITE. Found in large lumps in the lignites of Otago, New Zealand.

RHEEA, or RAMIE. (*The China grass plant*, a variety of *Böhmeria*). A dicotyledonous plant belonging to the natural order *Urticaceæ*. The order contains several species, which are distributed widely through the tropics and sub-tropics of both hemispheres; they are herbaceous plants or shrubs closely resembling our common stinging nettle, only the stinging hairs are absent. The same plant produces both the male and female flowers, but they are borne on separate spikes; the male flowers, consisting of a perianth of four leaves and four stamens, are cruciform; the female flower is tubular, having no stamens, but a slender style with hairs on one side. The Böhmeria contains tenacious fibres, which are manufactured in considerable quantities into useful articles. The *B. nivea* yields the fibre which is manufactured into the so called China-grass cloth: it is the Tchouma of the Chinese and the Rheea of Assam. This plant grows to about the height of three or four feet,

the leaves grow on long hairy foot stalks, are of a dark green on the upper surface, but covered on the under side with a thick coating of soft white hairs almost resembling down, which gives them the appearance of frosted silver. The fibre used for the manufacture of the grass cloth is obtained from the inner bark of the shrub, the bark being stripped off in two long pieces and all the useless matter is carefully removed with a knife; then the remainder is either steeped in hot water, or softened by exposure to steam, and the fine filaments are then easily separated. Young and quickly grown plants yield from the inner bark the most delicate fibres, from which the best grass cloth is made. This quality rivals in softness and fineness the best French cambric; but the outer bark of older plants is only used for ropes and sailcloth, and is said to be double as strong as the Russian hemp. It seems highly desirable that this fibre should be more generally used: its strength and durability are remarkable, and the plants are so easily grown that some of the species will grow on rubbish heaps, or under hedges, without the least care, only requiring to be protected from frost. If it could be manufactured more advantageously than it is at present, it would prove a source of considerable wealth. The Indian Government has recently offered prizes of 50,000 rupees and 10,000 rupees for the best machines or processes for preparing the fibre from the green plant: the trials will be made in India. The *B. puya* closely resembles the former in botanical character and general appearance, but grows to about double its height, sometimes reaching eight feet. It is a native of Nepal: it is called poosh or puya by the natives, who have long used its fibre in the manufacture of canvas or cordage, mud or clay being always used in its preparation, which greatly deteriorates its value. *B. albida*, a native of the Sandwich Islands, used for making cloth. *B. caudata*, a native of Brazil, used only medicinally.

RHODEIN. (ANILINE, vol. i. p. 177 and p. 186.) If to a certain volume of alcohol diluted with water to 40° we add a drop of pure aniline and then pure hypochlorite of soda, instead of obtaining the fugitive violet usual in aqueous solutions, we observe a yellowish coloration, passing sometimes into green, and sometimes into a permanent blue green. If aniline alone has produced the colour, there appears the rosy purple of rhodein, which finally fades into a yellow. If aniline and phenol are both present, the blue reappears in all its purity, and then also passes into yellow. To distinguish these two yellows, hypochlorite of soda may be added, which in the one case restores the fugitive violet of aniline, and in the other forms the blue erythrophenate, which the next day will be found to have retained its colour.—*Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences*, August 14, 1876.

RHODIUM. (See PLATINUM.)

RHODONITE. Red silicate of manganese.

RICE. Our imports of rice in 1876 were as follows:—

In the Husk.

	Qrs.	Value
From all countries . .	320	£423

Not in the Husk.

	Cwt.	Value
From Holland . . .	51,789	£60,219
" Siam	313,129	122,589
" Japan . . .	91,580	59,204
" British India:		
" Bombay and Scinde .	17,216	6,193
" Madras . . .	319,362	130,124
" Bengal and Burmah .	5,556,055	2,491,092
" Straits Settlements .	6,591	3,595
" other countries .	89,459	44,222
Total . . .	6,449,181	£2,929,138

RICE SHELLS. The *Concha veneris alba.* (See CONCH SHELLS, small.)

RICE STARCH. (See STARCH.)

ROCK-BORING MACHINERY. The application of machinery to the boring of holes for blasting purposes is a subject of considerable importance to the mine adventurer as well as to the miner. By means of boring machines shafts may be sunk, levels driven, and lodes explored in one-third of the time required to effect the work by manual labour alone, while dead charges, such as water, cost, management,

and maintenance of works may be proportionally lessened, and the chance of realising satisfactory results for the capitalists materially increased.

For many years rock-boring plant was of an unreliable character. Air compressors were faulty both in material and construction, the pipes frequently of insufficient diameter and badly jointed together, and the boring machines ill-contrived and of uncertain duration, while the carriages, stands, and stretcher bars were often so light and rickety as to lessen, and even to neutralise, the useful effect of the machines.

These various defects have now to a great extent been remedied. Practice and care have established the success of this class of machinery, and but little remains to be accomplished other than to apply the various apparatus on a scale commensurate with the work to be done. In fact, it may be safely asserted that rock-boring machinery is as essential to the rapid and economical development of a lode as the pumping engine itself, when the workings extend below the water line.

For the purpose of driving percussion boring machines at the bottom of shafts or in subterranean headings, pneumatic power is desirable. Such power can be transmitted to a great distance without difficulty, and will in its use not only supply air to workmen, but naturally aid in expelling the gases resulting from firing explosive compounds.

Mechanical boring, to afford satisfactory results, involves a well-devised system of working, in which time, the unit of cost and expression of the result, may be employed to the fullest and most beneficial extent. If a high rate of progress be required, two or more boring machines must run together, and the machines, whatever their number, mounted in such a way as to be readily shifted to any part of the face. Then, when the boring is complete, the tackle must admit of its being quickly withdrawn. The shot holes must also be readily charged and blasted, and the *débris* immediately removed. The apparatus necessary in connection with rock-boring machines consists of—

(*a*.) Compressing engines.
(*b*.) Air receivers.
(*c*.) Pipes for the conveyance of compressed air.
(*d*.) Railways for carrying the boring tackle.
(*e*). Carriages or stands for mounting the boring machines.
(*f*.) Rock-boring machines.
(*g*.) Rock-boring tools.
(*h*.) Water apparatus;

While a 'cut' or 'sink' includes:—

(*j*.) Boring the holes.
(*k*.) Charging and blasting the holes.
(*l*.) Removal of the stuff after the blasting operation.

(*a*.) *Compressing Engines.*—If boiler power is to furnish boring power through the medium of compressed air, a considerable deduction must be made from the former. Specifically stated, loss is incurred—

1. In converting boiler into engine power.
2. In converting engine into pneumatic power.
3. In passing pneumatic power (compressed air) through the transmission pipes.
4. In overcoming friction and changing the movements of the boring machines.

At the Blanzy Collieries, Montceau-les-Mines, France, considerable attention has been given to the subject of compressing air with the view of ascertaining the loss of power between the boiler and the boring machines. At that place two kinds of compressors are employed—one a SOMMEILLER, in which the speed is slow, the valves large, the air compressed in contact with water which fills the clearance spaces, and delivers the contents of the stroke into the receiver; the other a Blanzy compressor, in which the piston speed is comparatively high, the cylinder surrounded by a water jacket, and the cylinder covers fitted with spray jets in connection with pumps by which water is forced into the cylinder during the compression of the air. M. GRAILLOT, the mechanical engineer to the establishment, selected the former compressor for trial, and after a series of exhaustive experiments ascertained in general terms that the work charged into the receiver in the form of compressed air represented from 35 to 45 per cent. of the work due to the steam within the boiler, while the work obtained through the medium of boring machines was only 20 to 25 per cent. of the boiler work. It therefore follows that from *four* to *five* horse-power is required to afford *one effective* horse-power in the boring machines, and that the loss in transmitting compressed air from the receiver to the machines, and in changing the movements of the piston and its accessories, is from 15 to 20 per cent. of the power generated within the boiler. In other words, the power within the boiler is disposed of as follows —

Loss, in transmission from boiler to engine, and overcoming resistances in engine and compressor	0·65	0·55
Loss, in passing from receiver through transmission pipes, and in changing the movements of the piston and its accessories	0·15	0·20
Effective power obtained in boring machines	0·20	0·25
Total	1·00	1·00

The table confirming these general results, compiled by M. GUALLIOT, is subjoined, the figures being mostly according to the French metric system :—

Pressure per square inch	Lb.	62½	35½	63½
Revolutions of engine per minute		10-11	10-11	13-15
Water injected into compressing cylinder	Litre	·560	·560	·560
Temperature of water injected.	Morn. 71° Fahr., Even. 89° Fahr.			
Work due to the steam used in steam-engines	Kilos.	4801·80	3234·80	4460·00
Work absorbed by compressors	"	3620·88	2575·14	4029·00
Work absorbed by the friction of the machinery	"	740·72	659·36	431·00
Co-efficient of the useful effect of the steam	"	·82	·80	·90
Work absorbed by compressor, divided as follows :—				
Work absorbed in compression of air	"	1571·46	963·40	1655·64
" in expelling air	"	422·00	271·74	758·40
" in expelling water	"	25·46	13·75	25·46
" stored in receiver	"	1601·87	1326·53	1540·11
Work lost by the heating of the air	"	293·76	210·23	797·60
Volume of air drawn in by stroke of piston	Cub. mètre	044·530	060·260	054·000
" compressed at the ordinary temperature	"	035·230	054·400	035·300
Gross work produced by the steam	Horses	46·50	34·50	47·60
Effective work transmitted by the engines	"	36·75	27·60	43·00
" stored in receiver	"	17·10	14·15	16·17
Work transmitted to the levels, admitting that the borers only return 60 per cent. of the useful work	"	10·25	8·50	10·00
Proportion of available work of air to gross work of steam		0·36	0·41	0·35
Proportion of available work of air to actual work of steam		0·44	0·51	0·35
Proportion of actual work of air in machines to gross work of steam		0·22	0·245	0·209
Proportion of actual work of air in machines to effective work of the engine		0·26	0·32	0·23

The most important amount of loss in compressing air arises from the accumulation of heat. During compression, heat is expressed, the quantity increasing with the tension of the air. As heat is equivalent to work, it follows that if the former is accumulated within the air cylinder it must act in opposing the path of the piston, thereby constituting resistance, or otherwise, it must be abstracted by the application of a convenient body for that purpose. Fortunately, water is a suitable agent; hence it is that the air cylinder is frequently covered with a water-jacket, or provided with spray jets set in the cylinder ends. To favour the action of the water and to keep a cool cylinder, the velocity of the piston should be kept moderately low. Another source of loss of work, the consequence of which increases in importance with the degree of compression, is the clearance spaces at the ends of the cylinder. If these are not completely blocked, such spaces as may remain will be filled with compressed air, which will follow the piston in its back stroke, and prevent the access of fresh air to the cylinder until the inlet valve is relieved from internal pressure. Other sources of loss might be referred to, such as loss of effect resulting from the use of compressed air without expanding it in the working cylinder; but a careful investigation of the mechanical properties of air, together with the action of these properties during compression, and the subsequent use and return of the air to its normal condition will show that boring machines, as well as pneumatic engines, working under a pressure of two or three atmospheres, are much more economical in their draft on fuel than machines which demand a pressure of from five to eight atmospheres for performing their work.

Motors.—Air compressors may be driven by means of water-wheels, turbines, or water-pressure engines. At the ordinary speed of a water-wheel wet compressors may be directly attached to the crank shaft—or, if desirable, the power of the wheel distributed on a triple set of single-acting cylinders. The turbine usually runs at a high velocity; hence to connect the compressor with this kind of motor intermediate gear is required. At the Airolo end of the St. Gothard Tunnel twelve compressors have been erected in groups of three on one side of a common driving shaft, set in motion by four distinct turbines.

The water for driving the turbines is drawn from one of the branches of the Tessin, and falls about 630 ft., affording a static pressure of 270 lb. per square inch. The turbines make 300 to 400 revolutions per minute, and in the same time the compressors 80 to 100 revolutions. Water-pressure engines give a steady, but somewhat slow movement for running compressors direct. They may, however, be advantageously employed in localities where water is abundant at moderate falls, and some attention can be given to maintain the efficiency of the working parts.

Steam-Engines.—In some of the earlier compressing machines motion was transmitted from the engine to the compressing cylinder by means of spur-wheel gearing. This arrangement admitted of a high velocity in the steam piston, and a comparatively slow velocity in the compressing piston, but rendered the strain unequal on the teeth of the wheels, and sometimes led to their breakage.

The more recent practice is to couple the piston of the air cylinder to the crank, so that the maximum effect of the steam may be exerted at the time that the air is being delivered to the receiver, or to employ double steam and compressor cylinders, so that the power of one steam cylinder may overcome the resistance offered in the opposite air cylinder. In addition, it is sometimes desirable to provide the engine with a variable expansion valve, and to economise power by using steam on the piston of considerable pressure (five or six atmospheres), and cutting it off at from three- to five-eighths of the stroke.

(*a*.) Sommeiller's *Compressor*.—At the Marie Colliery, Seraing, and elsewhere in Belgium, Sommeiller's wet compressors are used.

2476

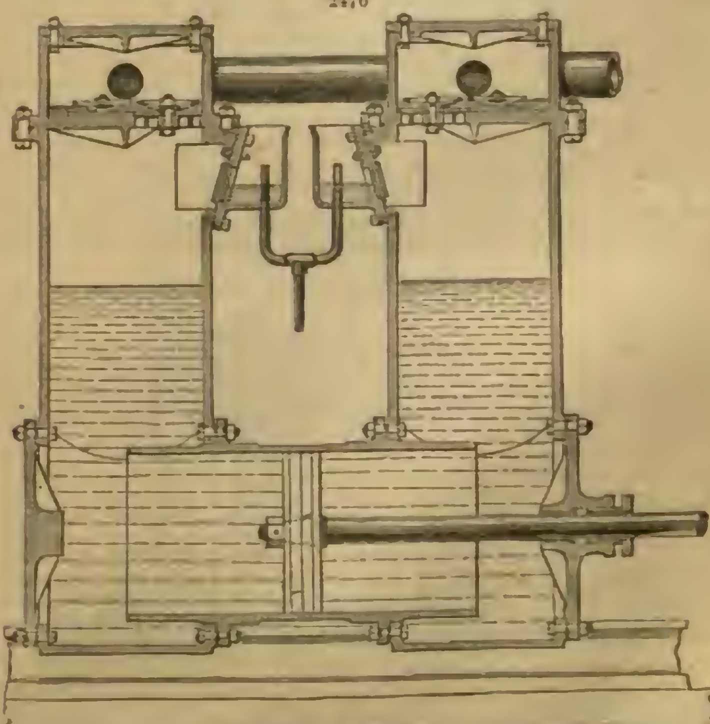


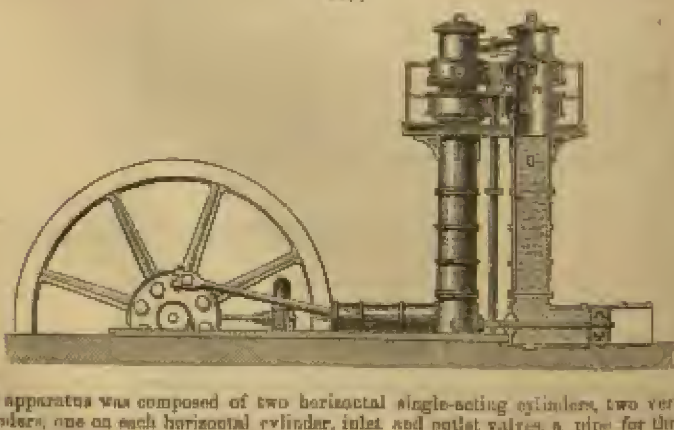
Fig. 2476 shows a vertical section through the centre of the cylinders. The piston moves horizontally in a cast-iron cylinder, which is kept full of water. From the two extremities of the cylinder spring two vertical cylinders, closed at their upper ends. The air is admitted through a rectangular opening in the side of the cylinder—the intake valve being of leather stiffened with wrought-iron plates as in the ordinary mine buckets. The discharge of the air into the receiver takes place from the upper part through rubber valves. The movement of the piston in the cylinder causes the water in the vertical columns to rise on one side and to fall on the other. Above the falling water a partial vacuum is formed, causing the admission valve to open, and the unoccupied space to be filled with air. When the piston returns in the opposite direction the water is driven back, and the air with it. The admission valve is closed, and as soon as the air is compressed to a pressure equal to that in the receiver the delivery valve opens. The water rises through and above the outlet valve, filling the clearance spaces, and driving into the receiver the whole of the air compressed. To avoid inconvenience arising from any corrosive action of the water the piston is made of brass, and the rod incased in brass. The steam cylinders are 10½ in. diameter; stroke 4 ft. These are fitted with variable expansive gear, the cut-off being usually at one-half of the stroke. The fly-wheel is 16½ ft. diameter, and weighs 128 cwt. The compressor cylinders are 17⅝ in. diameter. The minimum speed of the engine is five revolutions or 40 ft. per minute; the maximum 20 revolutions or 160 ft. per minute. The effective work exerted on this compressor is about 84 per cent. of the indicated engine work.

Carefully conducted experiments with a SOMMEILLER compressor erected at the Saarbrück Mines to supply rock-boring machines have been made with the following results:—

No. of Experiment	Useful Effect of the Compressor at		
	One Atmosphere	Two Atmospheres	Three Atmospheres
1	0·94	0·88	0·86
2	0·95	0·885	0·855
3	0·93	0·88	0·85
4	0·95	0·90	0·865
5	0·94	0·87	0·83
6	0·93	0·85	0·80
Mean .	0·94	0·877	0·84

Fig. 2477 shows one of SOMMEILLER'S compressors which was employed in compressing air for running the boring machines used in driving the Mont Cenis Tunnel.

2477



The apparatus was composed of two horizontal single-acting cylinders, two vertical cylinders, one on each horizontal cylinder, inlet and outlet valves, a pipe for the admission of water to the vertical cylinders, a branch pipe connecting the two valve

chambers, and a fly-wheel. The valve for inlet of air is shown at B; this valve is of leather, backed with an iron plate, and hung at its upper end, the 'seating' being sufficiently inclined to allow the valve to open as soon as a slight difference occurs between the internal and external pressure. The outlet, an ordinary flat valve, A, is of gun metal; the air enters through the inlet-valve opening, B, and after compression is expelled through the outlet-valve opening, A. The compression of the air is effected by raising the water within the vertical cylinder until the tension of the air is equal to that stored within the air receiver, when the further elevation of the water until it reaches the outlet valve effectually discharges the air from the vertical cylinder into the air receiver. The water discharged through the outlet valve at each half stroke of the piston flows to the receiver, from whence it is either drawn off occasionally or returned to the compressing cylinders through the small central pipe shown in the illustration.

2478

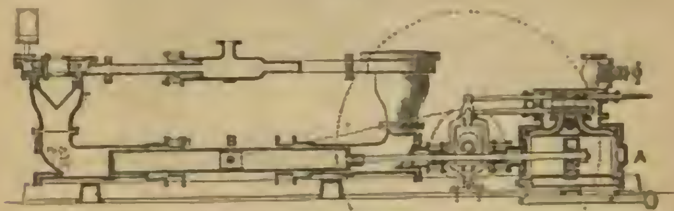


Fig. 2478 shows a compressor designed and made by the HUMBOLDT COMPANY near Cologne. The apparatus consists of a steam cylinder, steam, and variable expansion steam valves, a double-acting plunger with two side rods coupled to two fly-wheels, two valve boxes, one at each end of plunger case fitted with inlet and outlet valves. Water introduced into each plunger case serves the threefold purpose of filling the clearance spaces, expelling the air, and absorbing the heat given off during the compressing operation. The following are particulars of a machine erected at the Saarbrück Collieries. The motor is a horizontal expansion steam-engine—cylinder 24¾ in. diameter, stroke 43 in., with a pressure of 30 lb. of steam, and a cut-off at half-stroke; at 25 revolutions per minute 54 horse-power is developed. The compressor plunger is 15½ in. diameter and 12 ft. long. Each plunger case is 5 ft. long and 20 in. diameter; the branch at the end of each case is 33 in. diameter and 5 in. in height, upon which is placed a valve chest of enlarged diameter. The stuffing boxes of each case are distant 6 ft. from each other. In this space a cross-head attached to the middle part of the plunger and travelling in guides is connected to side rods attached to fly-wheels. With an air pressure in the receiver varying from 30 to 45 lb. per square inch, the useful quantity of air compressed is stated to equal 96 per cent. of the theoretical contents of the stroke. The following are the dimensions of some of the compressors constructed by the HUMBOLDT COMPANY:—

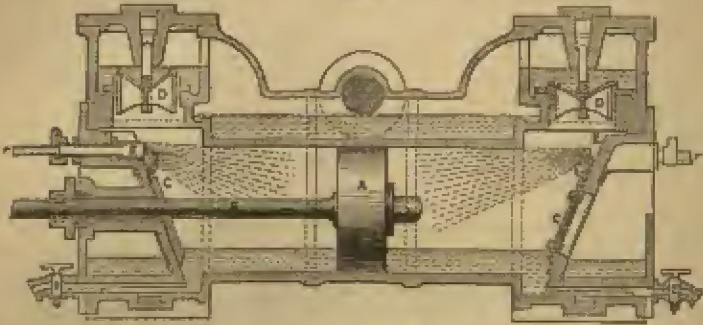
Number	Diameter of Air Cylinder	Diameter of Steam Cylinder	Length of Stroke
	In.	In.	In.
1	6	9	15
2	7½	10½	20
3	9	12	24
4	12	16	36
5	15	19	48

Horizontal Water Compressor.—A compressor has been erected at the Werister Colliery, Belgium, and at the Minera Lead Mines, near Wrexham; the latter, for a long period under the management of the late Mr. DARLINGTON, intended to combine the merits of the SOMMEILLER and the COLLADON compressors, that is, to compress the air in immediate contact with water, yet with a volume of water insufficient to preclude the engine from running at a high speed.

At Minera twin-cylinder steam and air cylinders are employed. A section of one of the air cylinders is shown in *fig.* 2479: A, piston packed with hemp gasket; B, piston rod; C C, inlet valves of leather stiffened with wrought-iron plates, hung to cylinder covers; D D, brass outlet valves. Spray jets are inserted in each cylinder

cover, and cocks for drawing off any excess of water which may appear to be necessary. The minimum speed of the compressors is 7 strokes per minute, maximum speed

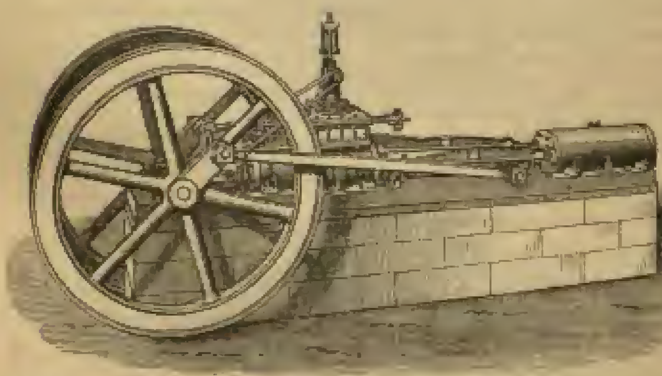
2479



45 strokes, or 225 lineal feet per minute. At 20 strokes per minute the theoretical volume of air compressed to a tension of three atmospheres, or 45 lb. per square inch, is 17¼ cubic feet, or, taking the actual result at 80 per cent. of the contents of the stroke, 13$\frac{8}{10}$ cubic feet.

Moonta Compressor.—*Fig.* 2480 illustrates a compressor arranged by DARLINGTON for driving rock-boring machines at the Moonta Copper Mines, South Australia. The steam and air cylinders are placed on one and the same bed-plate, the piston rods are cottered to a single cross-head, from which four side rods extend to two heavy fly-wheels. On the fly-wheel shaft two eccentrics are placed for working two vertical levers, to the ends of which are attached rods for shifting a variable expansion and an ordinary steam slide valve. The chest containing the valves is on the top of the

2480

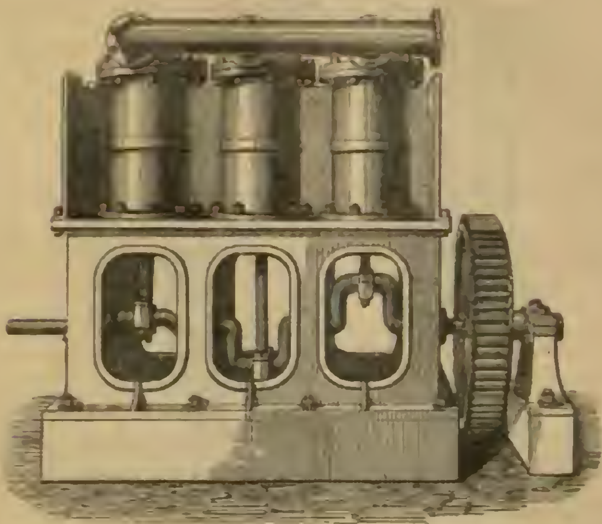


steam cylinders. The hand-wheel for varying the admission of steam is shown immediately over the piston-rod. The engine is provided with a pump for forcing water into an accumulator (see *fig.* 2483), which in turn delivers water under considerable pressure to a water jacket surrounding the air cylinder and to spray jets (see *fig.* 2485) into the inner part of the cylinder. The inlet and outlet valves in the covers of the air cylinders are of brass provided with leather beats. The stroke of the engine is 3 ft., diameter of air cylinder 20 in., speed of engine 40 revolutions per minute. The theoretical quantity of air at 60 lb. pressure, calculated at 70 per cent. of the cubic contents of the stroke, is 38 cubic feet.

Three-cylinder Compressor.—At the Rushen Mines, Isle of Man, a three-cylinder air compressor is erected for the purpose of accelerating the sinking of an engine-shaft and driving a main level on the lode by means of three DARLINGTON boring machines. Each cylinder is single-acting, the piston rods being connected with a three-throw crank (see *fig.* 2481). The cylinders are fixed in a water tank, while jets

of water play into each cylinder during the compression of the air. The inlet and outlet valves are set in the cylinder covers, the outlet pipe to air receiver being in connection with each outlet valve chamber.

2481



Diameter of each piston	13 inches
Stroke of piston	18 "
One suction valve in each cover, internal diameter 5 inches . .	19·6 inches area
Two discharge valves in each cover, diameter 3 inches, equal 7 inches area × 2	14 inches area
Theoretical volume of air per stroke	1·38 cubic feet
Or, for the group of three cylinders	4·14 "
At a speed of 50 revolutions per minute three cylinders will afford 4·14 × 50	207 cubic feet
Volume of air compressed to 50 lb. per inch at 70 per cent. of the contents of the stroke . .	$36\frac{3}{16}$ cubic feet

2482

Fig. 2482 is a diagrammatic illustration of twin steam and air cylinders mounted on an air receiver, especially useful for the completion of contractors' work when it may be undesirable to erect compressing plant of a permanent character. *a*, fly-wheel shaft; *b b*, fly-wheels; *c c*, sweep rods; *d*, safety valve on receiver; *e e*, steam cylinders; *f f*, rods connecting steam and compressor pistons; *g g*, suction and delivery valves; *h h*, air cylinders; *i i*, pipes from air cylinder to air receiver; *k*, stop valve; *l*, air pipe main, $3\frac{1}{2}$ in. diameter, extending from air receiver to the rock-boring machines.

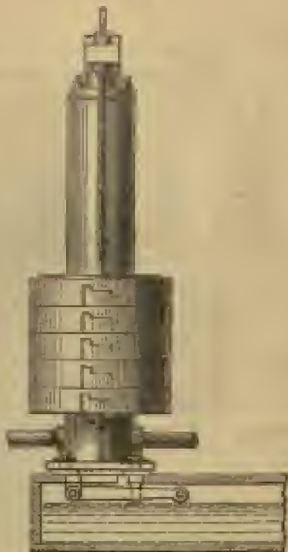
The air cylinders of a compressor arranged as shown in *fig.* 2482 for driving McKean's four-inch cylinder boring machines at Festiniog, North Wales, are 16 in. diameter, $2\frac{1}{2}$ ft. stroke, double-acting, and make 60 strokes per minute. The theoretical quantity of air compressed to 60 lb. per inch, at 70 per cent. of the contents of the stroke, is 146 cubic feet.

Accumulator.—For the purpose of delivering a continuous jet of water to the air cylinders, no matter what may be the required tension of the air, Darlington some-

times employs an accumulator (*fig.* 2483). This apparatus consists of a weighted plunger with a valve and lever at the bottom.

2483

2484



The accumulator is fixed in any suitable position for receiving water from a plunger worked by the steam-engine or other motor, and for delivering such water to the air-cylinders through spray-nozzles.

The illustration shows the inlet-pipe from the engine-plunger, the outlet-pipe to the air cylinder, pressure-weights surrounding the cylinder, suspended from the plunger head, relief-valve at the bottom of the cylinder, valve-lever lifted by means of one of the side rods, and a tank for receiving any excess of water which may be charged into the accumulator cylinder. This apparatus was first applied to the Moonta compressor (*fig.* 2480).

Instead of an accumulator, water may be returned to the compressing cylinders from the receiver, or water may be forced directly to the air cylinders by means of a force-pump arranged for that purpose.

Spray Jet.—In addition to the water-jacket which frequently surrounds the air

2485

2486

cylinder, water is in some cases introduced to the internal part of the cylinder in the form of a spray jet. The object of such spray jet is to present the water in

a form well suited for quickly absorbing the heat expressed from air during its compression.

Fig. 2485 shews a nozzle as constructed for various compressors, and *fig.* 2486 the manner in which the nozzles may be applied. The details of the nozzle are sufficiently well shown to require no explanation, it being merely necessary to observe that the diaphragm plate at the end is perforated with small holes in such a way as to direct one jet of water against another, so as to break the jets into spray. The water should be forced into the nozzle-piece under considerable pressure. *Fig.* 2486 illustrates two nozzle-pieces fixed near the end of an air cylinder.

(*b.*) *Receiver and Air-pipes.*—The receiver and air-pipes should be of sufficient capacity to annul the effects of the irregularity which might exist between the production and consumption of air; in other words, to run the boring machines steadily without much variation of pressure. The dimensions of the receiver, as well as the pipes, ought, therefore, to be in relative proportion to the number of machines to be worked, the cubic contents of air requisite for running the machines within a given period, and to the charging power of the compressor. No exact rule can be laid down for determining the dimensions of the receiver, but if its capacity be eight or ten times more than the volume of air required per minute for the use of the machines, it will probably be sufficient. Large receivers and air-pipes are desirable. The boring-machines, when well supplied with air, will not only deliver their blows more uniformly and with the desired effect, but the friction in passing air through large pipes from the receiver to the machine will become inconsiderable. The form of the receiver is a matter of small importance. An old boiler will effectually serve the purpose, provided the plates be strong enough. The receiver may be placed in any suitable position, near to or distant from the compressor, and to stand vertically or lie horizontally on the ground. At the Friedrichsegen Mine, in the Lahnthal, the receiver, about 30 feet high, is placed on its end, the relief-valve being at the top, the water circulating pipe at the bottom. To render the receiver complete it should be furnished with relief- and stop-valves (see *fig.* 2487), and if in connection with a wet compressor a blow-off cock and a pipe for returning water to the compressor cylinders, unless fresh cold water is available for that purpose. In such case the receiver should be fitted with an automatic arrangement for discharging the water when it attains a given height within the vessel.

2487

Table of Receivers.

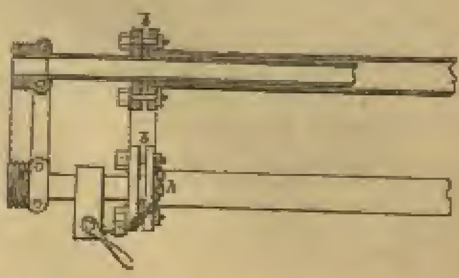
Localities	Compressors employed	No. of Compressors	No. of Receivers	Total Contents of Receivers in Cub. Ft.	Pressure employed in Rock Drill per Sq. In.	Machines employed
					Lb.	
Mont Cenis	Sommeiller's	8	14	28,000	90	Sommeiller's
Vieille Montagne	Dry compressor	1	1	180	30	Sach's.
Saarbruck	Humboldt	2	3	740	60	do.
Marihaye	Sommeiller's	2	6	4,250	75	Dubois and François'.
Ronchamp	do.	2	1	880	$67\frac{1}{2}$	do.
Anzin	do.	2	2	1,450	45	Various.
[illegible]	Sommeiller's and Henry	4	—	—	45	Darlington, Henry.

Localities	Compressors employed	No. of Compressors	No. of Receivers	Total Contents of Receivers in Cub. Ft.	Pressure employed in Rock Drill per Sq. In.	Machines employed
					lb.	
St. Gothard, Göschenen . .	Colladon's .	5	4	1,150	90	Ferroux, Dumas and François'.
Ditto, Airolo .	do.	9	4	2,225	90	McKean's.
Minera . .	Darlington's	2	1	200	50	Darlington's.
Marbella . .	do.	1	1	250	50	do.
Ballacorkish .	do.	1	1	250	50	do.
Foxdale .	do.	1	1	300	60	do.
Wheal Agar .	do.	1	1	320	60	do.
Moonta . .	do.	1	1	—	50	do.

(c.) *Air-Pipes.*—Compressed air must be conveyed in pipes from the receiver to the boring machines placed at various points underground. During this transmission a loss of work is occasioned by the friction of the air. The results of numerous experiments to determine the value of the loss thus occasioned show—1. That the resistance is directly as the length of the air main. 2. That it is directly as the square of the velocity of flow. 3. That it is inversely as the diameter of the pipe. The formulæ established from these results and conclusions show that for air-pipes of the diameters usually employed, and for the distances prevalent in mines, the loss of motive force due to the friction of the air in the main is insignificant when the velocity does not exceed 4 feet a second.

The pipes to form the permanent main from the receiver to the boring-machines may be of cast- or wrought-iron, but in either case they should be provided with faced and scored flanges. Cast-iron pipes are obtainable in 6 or 9 feet lengths; wrought-iron pipes in 12, 14, or 16 feet lengths. If wrought-iron pipes are to be used, cast-iron flanges may be screwed or soldered on the ends. Before cast-iron pipes are placed in position the interior surfaces should be well flushed with water and swabbed, in order to remove any loose sand or scale adhering to the sides. To complete the operation the interior surface should be covered with a non-corrosive paint. The inside of many a boring-machine cylinder has been partially destroyed through neglect of these simple precautions. The pipe-joints are readily and effectively made by means of a flat ring of vulcanised rubber. The expansion taking place in an air main is best taken up by means of a running joint, or by introducing a short bend of copper pipe. In the levels the main may be laid on the sole, or hung on the side towards the roof, the latter being a position frequently preferred. In some cases it will be useful to place one or more cocks on the main; one fixed at the commencement of the 'advancing' or terminal pipe is almost necessary. The advancing pipe is in some instances formed of one pipe sliding within another (*fig.* 2188), the inner one being drawn out as the forebreast of the level is advanced. To the end of this inner

2188



pipe is attached the flexible hose for connecting the permanent main with the boring machines.

When tunnels have to be driven a long distance, and time is of the greatest value, a

reserve main is sometimes fixed to supply air to the borers during the period when additional pipes are being added to the principal or working main. In metalliferous mines rock-boring machines will scarcely be required to operate at a greater distance than a mile from the seat of power, and as the number of machines will be more or less limited for some time to come, pipes of less diameter will suffice than if the air is to be conveyed a distance of 3 or 4 miles, as in the case of some tunnels already executed. For the general main, pipes 3 inches to 4 inches diameter will be large enough; for the secondary or branch part of the main, the diameter need not exceed 2½ inches or 3 inches, whilst for branches from this part of the main, to connect a series of three or four borers, the diameter may be reduced to 2 inches:—

Diameter of Air-Main.	First Part	Second Part	Terminal Part	Flexible Pipes
Railway Headings.	Inches	Inches	Inches	Inches
Mont Cenis	8	—	4	2
Hoosac	8	—	—	—
St. Gothard, Goeschenen	8	4	2½	2½
St. Gothard, Airolo	8	8	4	2½
Musconetcong, New Jersey	6	6	—	—
Portakewat	2	—	—	—
Festiniog	3½	—	—	—
Collieries and Mines.				
Anzin	4	4	2¾	2
Ronchamp	3½	—	2	2
Marihaye	3	—	2	2
Blanzy	6	2½	2	—
Vieille Montagne	4½	—	3	2
Friedrichsegen	2½	—	2½	2
Stahlberg	3½	—	2½	1½
Cwmbran, Newport	2[1]		—	—
Marbella, Spain	4	—	2	1½
Maesteg, Bridgend	4	—	—	—
Wheal Agar	3	—	3	1½
Minera	3	—	3	1½
Carn Brea	3	—	2	1
Ballacorkish	3	—	—	—
Foxdale	3½	—	—	1
Dolcoath	2	1½	1½	1
South Crofty	2	—	—	—
Moonta, South Australia	3	—	1½	1

(*d.*) *Railways.*—In tunnels or mine headings driven in Europe a single railway is generally laid for the borer carriage, and waggons necessary for the removal of the *débris*. In one or two instances the borer carriage has been placed on a wide railway, and the stuff removed by means of waggons running on a narrower gauge line. The advance headings in Europe scarcely ever exceed a width of 9 feet. In America, however, the whole width of the railway tunnel is sometimes carried in the advance heading, which renders a double and spare line of rails necessary. In driving mine levels the gauge of the carriage rails may have to conform to the gauge of the waggon required for the removal of the stuff. If no special considerations were necessary other than to determine the best gauge for the borer carriage, the gauge might be fixed at 2½ to 3 ft., and the weight of rails from 16 lb. to 20 lb. per yard. In long headings, and where boring carriages are employed, it may be desirable to cut stalls at from 50 to 100 fms. apart for the lodgment of the carriage and boring machines during the time of blasting the shot holes and effecting the removal of the stuff. Such stalls will also be found very useful for receiving the men during the firing operation, for holding the boring tools, machine oil, or, when electric blasting is employed, the apparatus required for igniting the fuses.

[1] To be replaced by pipes 4 in. diameter.

Places	Gauge of Single Railway laid in Middle of Level	Width of Advance Heading	Height of Advance Heading	Area of Heading in Square Feet
	Ft. in.	Ft. in.	Ft. in.	Ft. in.
Mont Cenis . .	3 3⅜	9 10	8 0	81 7
St. Gothard, Göschenen	3 3⅜	8 10	8 2	72 2
" Airolo .	3 3⅜	8 0	8 2	65 5
Vieille Montagne .	4 0	7 4	7 4	53 9
St. Leonard's . .	1 11⅝	6 7	6 7	43 4
Marihaye . .	1 7⅝	7 3	7 3	52 6
Ronchamp . .	2 1⅝	7 9	7 3	52 6
Anzin . . .	1 11⅝	7 10	7 3	56 9
Friedrichsegen . .	2 0	7 0	7 0	49 0
Blanzy . . .	3 3	7 0	7 0	49 0
Gothardbahn . .	3 3⅜	7 0	7 0	49 0
Marbella . . .	2 0⅝	7 0	5 0	35 0
Cwmbran . . .	3 0	10 0	7 0	70 0
Maesteg . . .	—	10 0	9 0	90 0
Musconetcong . .	4 0	27 0	8 0	216 0
Hoosac Tunnel . .	—	24 0	9 0	216 0
Portskewet . .	1 8	8 0	8 0	64 0
Minera . . .	2 0	6 6	7 3	47 0
Drybrook . . .	2 0	6 0	7 0	42 0

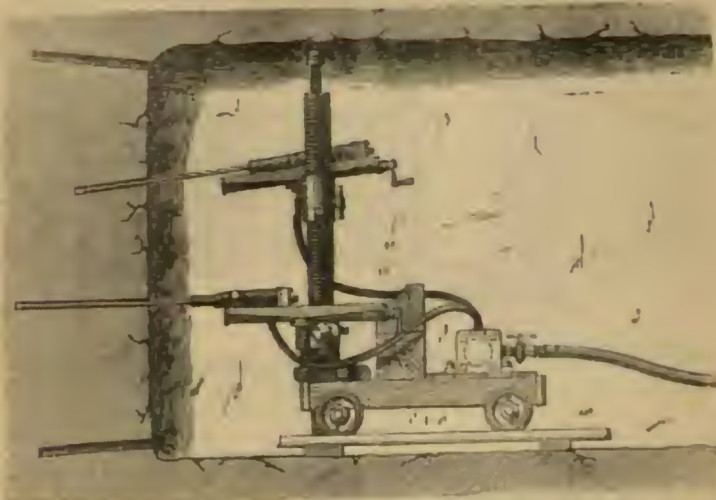
(*c*.) *Carriages.*—The effective working of rock-boring machines is more or less dependent on the construction and weight of the carriage on which they are mounted. If the face of a heading be of moderately large area, and the work is to be done quickly, several machines must be mounted together in such a manner that each can operate on a small but distinct portion of the face. Further, if time, as it always should be, be of primary importance, the fastening of the carriage to the sides or roof of the level may be dispensed with; but in such case the carriage must be of sufficient weight to absorb the recoil of the machines when in full operation. When a large number of men are employed in connection with the boring machines, it is important to save from 15 to 20 minutes in fixing the carriage. If four 'cuts' or 'advances' are to be made in 24 hours, as at St. Gothard, the time occupied in simply fastening and unfastening the carriage would be $\left(\frac{15 \times 2 \times 4}{60}\right)$ 2 hours, or 12 hours weekly. On the other hand, a heavy cumbersome carriage in a mine level would be scarcely admissible; nor is it of equal importance in point of economy as in the case referred to, since it must always happen, with the exception of some particular work, that mine headings will be driven by fewer men, unassisted by the 'fast speed tackle' employed in railway and special tunnelling. For mining purposes, therefore, the conditions have suggested a lightly-formed carriage, with means for fastening it to the sides or roof of the level, and an arrangement of vertical or horizontal bars, constituting a stand for carrying the machines.

In running boring machines it is either necessary that the tools shall have very easy play—in other words, be free from any restraint to take the line of the hole—or that the machines be rigidly attached to the retaining bars, so that the tools cannot deviate from the direction of the hole. If, in the latter case, any movement from the first position of the machine should occur, the tool will drag and grind itself on the side of the hole, the force of the cutting blow will be more or less dissipated, or, perhaps, the tool will bind and stop the machine; while a tool worked in this way, deprived of its corners and rounded at the point, will form a taper, not a parallel, sided hole, and cause the next tool with its fresh cutting edge to wedge itself tight in the taper part of the hole referred to. The proper construction of the carriage and attachment of the boring machine is, therefore, a very important part of rock-boring apparatus.

Heavy Carriages.—The Mont Cenis carriage held the boring machines, and withstood the reactive force of the blows by its weight alone. This weight was 17¾ tons. While the machines were at work one or two of the workmen frequently placed a piece of timber between the carriage and roof, to prevent a backward movement of the carriage. The boring machines were articulated to vertical bars, and allowed to play to and from the line of the holes. At St. Gothard a similar method of mounting the machines was adopted. At the commencement of the heading a carriage weighing from 4 to 5 tons was employed; but this was found too light for resisting the force of the blows and a heavier carriage was subsequently adopted.

Light Stands.—A DARLINGTON stand, employed for driving mine headings, is composed of a vertical and two horizontal bars. The vertical bar is clamped to the roof during the boring operation; the side bars are set so as to require but once shifting to bore the whole number of holes. In order to use this stand with ease and facility, it is taken to and from the forebreast on a small trolly arranged for that purpose.

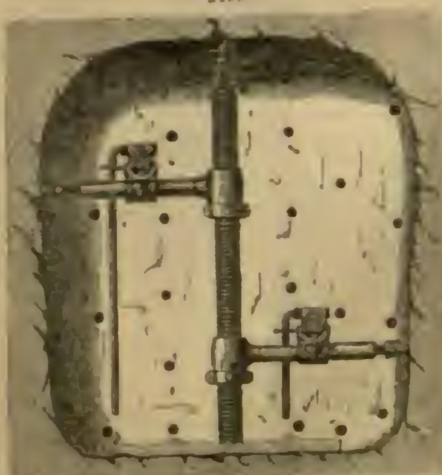
2489



This trolly is also fitted with a small platform for holding the boring machine, as well as an air cylinder having one inlet from the air main, and two outlets, one connecting each machine by means of a short piece of rubber hose. The arrangement of this stand is such as to admit of boring the holes and blasting the ground in vertical or horizontal 'cuts' as may be desired.

Fig. 2489 represents a vertical side elevation of the trolly, clamping column, the machine arms, and boring machines. The column is shown attached to the trolly,

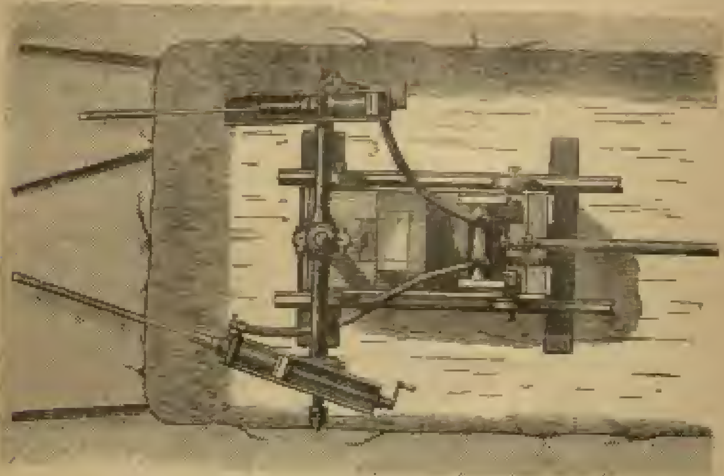
2490



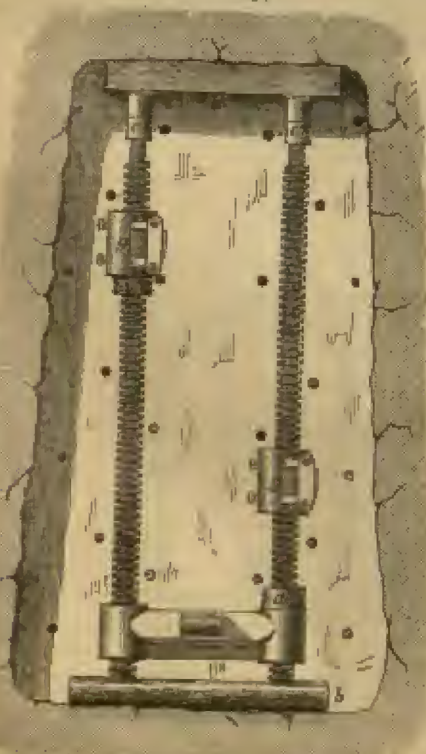
but before the machines are set to work it is disconnected, and the trolly shifted about two feet to the rear; this separation of the trolly from the column allows the

men to circulate freely from one side of the column to another. When the machine stand is to be withdrawn, it is detached from the top and sides of the level, clamped

2491



2492



to the trolly, and dropped, so as to lie at an angle of 45° or thereabout to its vertical position on the bench of wood shown on the trolly between the column and air cylinder: the machine arms, with the machines attached, are turned, so as to lie on the wooden bench referred to. *Fig.* 2490 represents a vertical front elevation of the stand without the trolly, the boring machines in position, and the holes supposed to be bored. To drill these holes the upper and lower arms are unclamped once during the boring shift, turned, and clamped to the opposite side; these operations, together with the angling and traversing range of the machines, suffice to secure the requisite positions for drilling the holes. *Fig.* 2491 shows the stand and trolly in plan. In this view the boring machines, horizontal arms, air cylinder, platform of trolly, and rails are clearly shown. The method of boring the holes from a fixed point on the bar simply by angling the machines is also rendered apparent. The face of the level exhibits twenty-eight holes. These holes, each about 3½ feet deep, are bored in silicious limestone in from five to six hours, three men being necessary

—viz. one man to each machine, and one man between the machines, the machine bars, and the face. The duties of this third man are—to change the tools, oil the piston-rods, direct the 'bits' on commencing the holes, and to supply the holes with water. A second form of light stand for carrying two boring machines, arranged for drilling holes parallel to the sides of a heading, is shown in *fig.* 2492. The stand includes two vertical columns, with a screw-thread cut on the surface of each, these columns being braced together at the bottom. *a a*, nuts for keeping the machine clips at any desired position; *b*, piece of timber upon which the column rests when in its working position, *c*, jack-heads for screwing the columns fast to the piece of timber, *d*; *g g*, clips to which the boring machines are fastened. In using this stand the clips can be turned around the columns, so as to allow the machines to work on either of the sides, while by loosening the set screws on the clips, and dropping or raising the nuts immediately under them, any vertical position in the heading may be secured for the boring machines.

Blanzy Stand.—This stand (*fig.* 2493) is employed at the Blanzy Mines, Montceau-les-Mines, France, for the purpose of running four Darlington boring machines in single headings. It consists of two vertical screws, a central vertical stay-piece, four horizontal arms, one for each boring machine, and a wrought-iron carriage frame supported on four cast-iron wheels. In order to bring the machines to any required point on the face of a heading, the machines are not only free to slide on the short

2493

horizontal bars, but the bars themselves can be raised or lowered on the vertical screws by turning the nuts underneath the boss ends. The distance between the two vertical bars is governed by the intended width of the level. With a 2 ft. 2 in. gauge of railway, and a level 6½ ft. wide, the screw columns are 4 ft. 8 in. apart from centre to centre; and the horizontal or boring machine arms 2 ft. long. This form of stand admits of boring the shot-holes so as to remove the ground either by vertical or concentric 'cuts.'

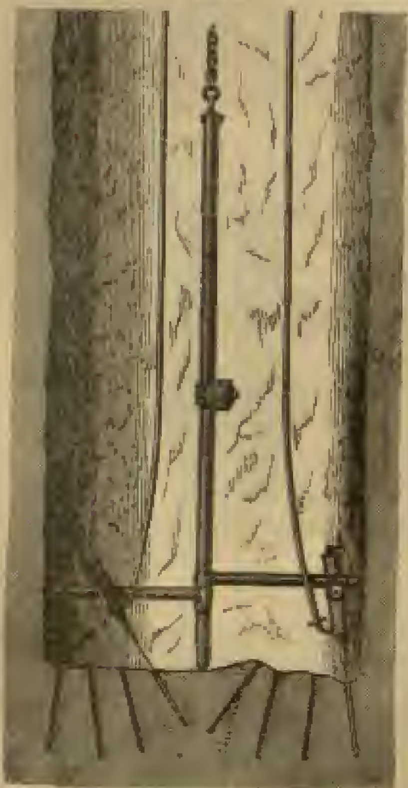
Shaft-sinking Stands.—Hitherto most of the boring machines employed for shaft-sinking purposes have been mounted on a stretcher-bar. In the year 1874 Dubois and François constructed a stand for sinking a pit 10 ft. diameter at the Werister

Colliery, Belgium. The stand, 24 ft. long, was formed of a wooden framework constituting its upper part, two vertical bars extending from the framework to the bottom of the shaft, and two horizontal bars, set 11½ ft. from the floor of the shaft, for carrying the machines. The horizontal bars were not fastened to the sides of the shaft, but the ends were clipped in an iron ring attached to the under part of the wooden frame.

Stretcher Bar.—This bar is simply fixed against the sides or roof and floor of the level, by merely lengthening it when in position. The machine is fixed to this bar by means of a clamp, which, when loosened, allows the machine to be directed at the desired angle. In order to use the stretcher-bar the machine must be very light.

The DARLINGTON'S *Shaft-sinking Stand.*—At the Minera Mines, North Wales, it was necessary in the year 1876 to continue the sinking of READ'S Shaft from the two-

2494



hundred-yard level, and to do the work quickly by means of rock-boring machinery. The shaft contained a pump 8 in. in diameter, and a single kibble way. The diameter of the shaft was 5½ ft. Two rock-boring machines were the most that could be advantageously employed. For the purpose of saving time, obtaining a rigid resistance to the action of the machines, and shifting the machines readily from one part of the bottom to another, a vertical bar and two horizontal rotary arms were employed, see *fig.* 2494. The stand is used thus:—The horizontal arms are set 3½ ft. and the piece of timber for supporting the vertical bar 6 ft. from the bottom of the shaft. The arms are then clamped to the sides of the shaft, and the boring machines worked and shifted on the bar, so as to bore the holes shown in the section.

When the whole number of holes are drilled, the bars are unclamped, the vertical bar loosened from the stay-piece of timber, and the apparatus lifted 20 or 30 ft.

As soon as the shaft bottom is cleared, say to a depth of 3 ft. for a second boring shift, the bar is dropped to the bottom and clamped to the stay-piece, this time 9 ft. from the bottom. As the vertical bar is 18 ft. long, it follows that four sinks of 3 ft. each can be made before it is necessary to place a second clamping piece within 3 ft. of the bottom.

(*f*.) *Rock-boring Machines.*—The first inventor of a rock-boring machine seems to have been TREVITHICK. In the year 1813, when his attention was directed to the subject, Cornwall was not only the chief seat of mining industry, but, through the startling improvements effected in the steam-engine by WATT, MURDOCH, TREVITHICK, WOOLF, and others, an impetus was given to mechanical inventions which extended far beyond the confines of the county, and men were stimulated at home and abroad to substitute as far as possible mechanical appliances for manual labour. Some forty years, however, passed away before the idea of boring shot-holes by means of machinery was rendered practicable. The exigencies of the Mont Cenis Tunnel induced BARTLETT to devise a steam rock-boring machine. Later SOMMEILLER invented the machine which bore his name, and showed how it could be worked by compressed air. Following SOMMEILLER's success in the Mont Cenis Tunnel, Italian, German, French, Swedish, American, Australian, and English engineers addressed themselves to the subject of inventing, contriving, and improving rock-boring appliances. Machines 10 ft. long, beset with complicated gear, are now replaced by machines 3 ft. long, presenting little more than the cylinder, valve, and a forwarding device. All real and permanent improvements have tended in the direction of increased strength and simplicity of parts. In more particularly tracing the development of inventors' ideas for expediting tunnelling and mining operations, it will appear that they group themselves into—1, forming the shot-hole by a revolving drill, and blasting the hole itself; 2, removing the entire area of the heading without the use of an explosive, either by means of a huge percussive, or a pressure cutting machine; 3, boring shot-holes by means of a small percussion engine. The failure of the first method, that of employing an ordinary steel tool in hard silicious rock, was soon rendered apparent; the tool, instead of abrading the stone, was almost immediately destroyed. The second method—substituting mechanical, for mechanical and chemical force, also proved objectionable when applied to hard crystalline rocks. Apart from such machines, blocking as it were the forebreast, the mechanical power required for performing the work was not only excessive, but the progress slow, and the greatest difficulty experienced in keeping the tools in condition for doing their work. The third method—the use of percussion borers in combination with chemical force, is the one which has been, and is likely to be, attended with permanent success. In perforating a heading with the requisite number of shot-holes, only a minimum expenditure of mechanical power is required; the chief work, that of removing the rock, being effected by the superior agency of chemical force instantly developed by the detonation of an explosive compound. In a percussion borer the movements required to form a hole are of a threefold character—1, a reciprocatory movement of the piston and tool to disintegrate the rock; 2, turning the piston and tool during the reciprocatory movement; 3, advancing the tool as the hole is deepened.

In one or two machines before the public these movements are automatically performed, and such automatic movements are desirable when four or six machines are worked together; but the forwarding or advance movement will be liable to fail in its object unless the rock be of uniform structure and hardness. In other boring machines the automatic movements are confined to the reciprocation and rotation of the piston, while in some, the piston and tool are rotated by hand. When only a single boring machine is in use, a merely reciprocatory movement may suffice, but the rejection of a simple automatic arrangement, for rotating the piston and tool, is by no means desirable. In many cases the object of an inventor has been to make his machine light, and of small dimensions. As the miner has greatly encouraged the idea of employing a light machine, it may be observed that this condition in itself has rendered light machines all but useless for practical work, and enabled the miner to cite instances of failure where success could hardly have been expected.

To perforate a face of rock quickly several conditions must be observed:—1. The machines must perform their work with certainty. 2. The number of machines should bear some general relation to the area of the face. 3. Stands are requisite for carrying the machines, not only as a means to keep the 'bit' in line of the hole, but to admit of angling and shifting the machines quickly.

Further, the use of stands will permit the workmen to exercise much freedom in their movements, and allow of the employment of machines which will run holes 30 inches deep without changing the tool and from 6 to 10 feet deep altogether.

Table of Boring Machines.

Year of First Application	Name of Inventor	Reversal of Stroke	Rotation of the Piston	Advance of Boring Machine
1857	SOMMEILLER	D valve worked by rotary engine	Gearing worked by the rotating engine	Tappet, clutch gear, screw with part of a nut worked by the same rotary engine.
1863	SACHS	D valve worked by piston-rod and angle lever.	Ratchet wheel worked by angle lever	Pair of screws, ratchet and angle lever.
1868	DUBOIS and FRANÇOIS	D valve worked through air pressure by two auxiliary pistons, conical valve, tappet on piston-rod and angle lever.	Two auxiliary pistons, moved through the variation of pressure in the air-channels, work a side lever and ratchet.	Hand-power.
1869	BURLEIGH	D valve worked by an annular cam on piston-rod.	Pair of screws and ratchet-nut	Pair of screws, ratchet, single lever and tappet, or by hand-power.
1869	OSTERKAMP	Cylindrical valve worked by air-pressure	Bevel wheels and ratchet wheel worked by the valve-rod.	Hand-power.
1872	MCKEAN	Oscillating valve worked by annular cam and tappet levers.	Screw and ratchet-nuts	The valve-rod moves a nut whose screw is fixed in a frame.
1873	DARLINGTON	Without slide valve, the piston itself effects the distribution of air.	Nut in piston, rifled bar and ratchet wheel	Hand-power.
1873	AROLINO DELL' AQUA	Distributing cocks worked by piston-rod through tappet and spiral slot.	Tappet on piston-rod and curved slot	The same as for the twist.
1873	FERROUX	D valve worked by rotary engine	The same rotary engine	Pressure of air on separate piston.
1873	INGERSOLL	Valve moved by piston through tappets	Nut in piston, rifled bar, and ratchet. JORDAN and DARLINGTON'S system.	Screw and ratchet-nut worked by tappets.
1873	CRANSTON	D valve worked by annular cam	Rifled bar and ratchet wheel	Hand-power.
1873	BRAYTON and DAVISON	D valve moved by a lever between two pistons.	Screw of large pitch and ratchet	Hand-power.
1874	WARSOP	Rotary valve worked by the pistons	Hand power	Hand-power.
1875	BARROW	D face valve and annular cam between pistons	Turned by hand	Hand-power.
1875	DUNN	D valve shifted by BURLEIGH tappet	Nut in piston, rifled bar and ratchet wheel. JORDAN and DARLINGTON'S system.	Hand-power.
1875	ULLATHORNE (Champion drill).	Oscillating valve shifted by spiral slot and stud.	Nut in piston, rifled bar, JORDAN and DARLINGTON'S system.	Hand-power.
1876	BEAUMONT	Air-moved valve	Automatically, spiral slot and ratchet wheel. JORDAN and DARLINGTON'S system	Automatically.
1876	GEACH	Balance piston valve worked by an annular cam and a BURLEIGH tappet.	Rifled bar through a ratchet wheel, BURLEIGH system.	Hand-power.
1877	JORDAN	The valve piston lifted by a small cam	Turned by small cam	Screw feed.
1877	SCHRAM	Air-moved valve, CHRAAK'S system	Nut in piston, rifled bar and ratchet wheel, JORDAN and DARLINGTON'S system.	Hand-power.

General Dimensions of sundry Rock-Boring Machines.

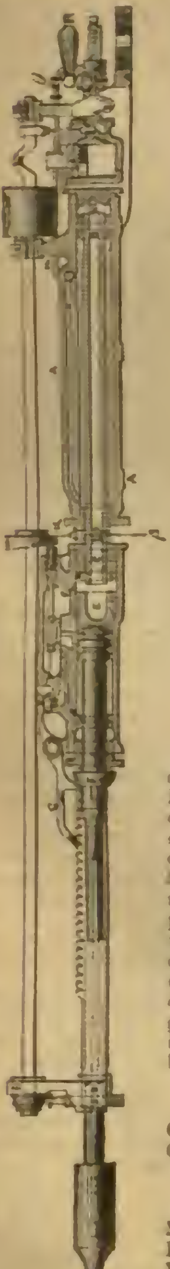
Name of Inventor of Machine	Diameter			Area		Approximate Length of Stroke	Approximate Number of Strokes per Minute	Remarks
	Piston Cylinder	Back Rod	Piston Rod	Piston for Blow	Piston for Return			
	In.	In.	In.	In.	In.	In.	In.	
Sach	2¼	1	1½	4·12	2·44	5	400	Double-acting
Osterkamp	3	—	2 1/16	7·06	2·54	4–5	220	Single-acting
Ferroux	3½	—	2¾	9·6	3·7	4–5	—	Double-acting
Darlington	2¾	—	2¼	5·9	3·7	3–4	500	Single-acting
„ Blaney	3	—	2	7·0	3·9	3–4	500	Double-acting
Dubois & François	2¾	—	2	5·9	2·76	5–6	250–300	„ „
McKean	4	1¾	2½	10	5·1	3–4	500	„ „
McKean	3	1¼	2	6·84	2·7	3–4	500	„ „
Burleigh	4½	3	3¾	8·84	4·86	5–6	300–400	„ „
Kainotomon	3½	—	2	9·6	6·5	3½–4	200–300	„ „
Barrow	4	—	—	12·5	—	4	—	„ „
Ingersoll	3½	—	2¼	9·6	5·63	5–6	300–400	„ „
Beaumont	4	1¾	2¾	11·08	6·6	4–5	—	„ „
Dunn	3	—	2	7·06	3·92	3½	200–300	„ „
Champion	3	—	2	7·06	3·92	—	—	„ „
Schram	3	—	2	7·06	3·92	3½–4	400–500	„ „
Grach	3¼	1½	2¼	7·86	5·65	3½–4	400–500	„ „

The Ferroux *Rock-Boring Machine.*—This machine, employed in the St. Gothard Tunnel, in its general arrangement resembles Sommeiller's machine, which was used in forming the Mont Cenis Tunnel. In Ferroux's machine the triple operation of drilling, rotating the piston, and advancing the tool are automatically performed; but to obtain these movements the machine is necessarily of considerable length. The rotation of the tool and movement of the air valve are effected by means of an oscillatory engine placed at the end of the advance cylinder. The advance cylinder is set next to the oscillatory cylinder, and is fitted with a cupped leather piston, the back or superior end of which piston is subject to the pressure of the motive fluid. The percussion cylinder in front is fitted with a slide valve shifted by a rotary disc-shaped cam. The front of the piston rod immediately outside the cylinder gland is furnished with an annular cam, the object of which is to lift a trigger lever from the ratchet bars, so that the pressure on the forwarding piston may thrust the percussion cylinder and boring tool forward to such an extent that the trigger end of the lever is advanced beyond the action of the cam, thereby allowing the opposite end of the lever to drop into the ratchet bars, and thus stay the advance of the tool and cylinder. *Fig.* 2495: A advance cylinder, B forwarding piston, C coupling, connecting piston rod of forwarding piston, with head of percussion cylinder, D inlet pipe and cock, E head of percussion piston, F annular cam for lifting the forwarding trigger lever, G trigger lever. The motive fluid is supplied by the main pipe D to the advance cylinder by a small pipe *m*, upon which is a regulating cock *r*, to the oscillatory cylinder by a small bent pipe, and to the percussion cylinder by a passage in the valve box. Some improvements have recently been effected in this boring machine, shortening its length and simplifying some of its details.

The Darlington *Boring Machine.*—A screw boring machine is shown in *fig.* 2496, mounted on a stretcher bar; and a cradle machine in *fig.* 2489, attached to a level driving stand. In *fig.* 2496 the cylinder, entirely round, is provided with a screw thread; this screw-threaded cylinder passes through a clamping nut. In this machine no valve is employed; the pressure fluid is admitted and exhausted by means of the piston passing, suitably placed portways in the cylinder itself. The gear for turning the piston and boring tool is set within the head of the cylinder, and the cock for the admission of air is immediately under the handle employed for advancing or withdrawing the tool and cylinder. The screw machine, *fig.* 2496, is formed of three parts—(1) the cylinder, (2) the piston and its rod, (3) the turning gear. The number of strokes per minute may be rendered many or few as may be required. A short lap on the piston will admit of making a great number of short strokes per minute; a long lap will afford a long stroke, but the number of such strokes per minute will be proportionally decreased. In turn a light or heavy blow may be obtained simply by partly closing or opening the inlet cock. These advantages are of great moment in applying the machine to hard, soft, jointy, or cavernous rocks. With a pressure of

50 lb. of compressed air per inch on the piston, a 1¼-inch tool will penetrate hard sandstone at the rate of ten inches per minute.

2495



2496

Among the results obtained by the use of these machines, those connected with the sinking of an engine shaft at Ballacorkish Mine, Isle of Man, may be noticed. Rock, tough clay, slate enclosing strings of quartz; diameter of shaft, 10½ ft.; area, 86 square feet; depth of shaft from surface, 50 fathoms; number of shot holes bored in bottom of shaft, 22 to 24; diameter of holes, 1⅛ inch; depth of shot holes, 3½ to 5 ft.; number of boring machines employed, 2; pressure of air required, 45 lb. to 55 lb. per square inch; number of men employed, 9; lineal depth sunk weekly, 12 ft.; time occupied in boring the holes, 21 hours; in charging and blasting the shot holes, 12½ hours; in hauling the stuff, 73 hours: total, 106½ hours; to which must be added, dropping the pumpwork, 10 hours; hindrances, 11 hours: together, 21 hours. The following are the relative results attending the sinking of this shaft by hand, and by hand supplemented by machine labour:—

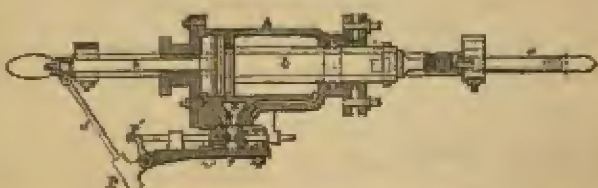
	Hand Labour			Hand and Machine Work		
	£	s.	d.	£	s.	d.
Contract price	31	0	0	13	0	0
Compressing air	—			1	0	0
	31	0	0	14	0	0
Number of men employed	12			9		
Lineal depth sunk per week	2¼ ft.			12 ft.		
Wages earned weekly per man	18s.			45s.		

At the Minera Mines, North Wales, in driving on a vein enclosed in the mountain

limestone, nine men, with the assistance of one boring machine, drove nearly 18 feet of level for the week ending November 9, 1877, against 3 or 4 feet practicable by hand labour alone.

Sachs' Boring Machine.—In 1864 CARL SACHS was occupied with HERRN O'BILHARZ, at Altenberg, in perfecting rock-boring machinery. About the year 1868 SACHS produced the machine which bears his name. On December 12, 1872, the machine in a perfected form was patented in this country. The lightness of the drill has induced Prussian engineers to employ it somewhat extensively both in metalliferous mines and collieries. The drill employed in ordinary mine-levels has a cylinder, A, $2\frac{1}{4}$ inches diameter; piston rod, b, $1\frac{3}{8}$ inch; and back rod, 1 inch diameter. The valve is a simple plate, one face being on the portways leading to and from the cylinder, the other retained by a plate carrying the valve arbor. The top end of the back of piston rod carries a ring, to which is attached a small rod, p, for working the valve shaft; to this is also attached a horizontal rod, which carries two pawls—one for rotating the piston, the other for advancing the cylinder. The cylinder, A, is mounted on two side bars not shown in the illustration. At a fluid pressure of 35 lb. per square inch the piston makes 400 strokes per minute, the length of stroke being 5 inches. The blow pressure is 116 lb.; return pressure, 72 lb. About 45 cubic inches of air or steam are required per stroke, or 38 strokes per cubic foot.

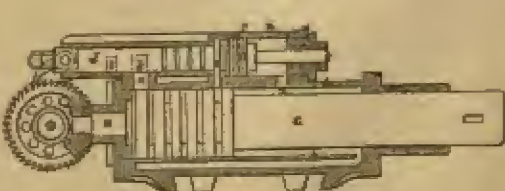
2407



The following results were obtained with this boring machine in a new sinking at Nornberg, near Steele, in Westphalia. The shaft, measuring 14·6 feet by 16·4 feet, was sunk in slate and sandy shale to a depth of 241·2 feet in six months, or an average of 40·2 feet per month, using six machines. The borers of best Styrian steel required sharpening after boring from 3·28 to 5 feet, and under the most favourable conditions a machine held out from thirteen to twenty-two shifts without requiring to be removed for repairs. The proportion of machine- to hand-bored holes was 2·72 to 1. The former averaged 3·9 feet in depth and from 1·2 to 1·5 inch in diameter, while the latter were 2 feet deep and 1 inch diameter. Blasting was effected with dynamite and safety fuse. The total number of hands employed at the shaft bottom, including those employed in filling the kibbles with stuff, was from 20 to 24. The cost per foot of this sinking was at first 5*l.* 8*s.* 0*d.*, but was subsequently reduced to 4*l.* 10*s.*, exclusive of the cost of drawing the stuff to surface. With the same machine at the Carolus Magnus Colliery, near Berge Borbeck, the average result obtained in driving a level through similar rock, 8·2 feet high and 7·2 feet broad, was 31·5 feet per month.

OSTERKAMP's boring machine was patented in England on May 20, 1870. The machine consists essentially of a cylinder, A; piston and rod, C; piston-valve, D; the

2408



rod of the piston valve, D, carries a pawl on its upper end, which operates on a ratchet wheel, which wheel rotates a spindle, E, passing through the end of the cylinder into the piston head, and produces the turning movement required. The cylinder is mounted on a slide rest or cradle, not illustr ted. The weight of an

OSTERKAMP machine, having a piston 3 inches diameter, piston rod 2·6-10ths inches diameter, is 50 lb.; weight of tripod stand, 66 lb. The machine bored a hole in coal sandstone 1½ inch diameter, 8-10ths of an inch deep, in one minute; and in the same time a second hole, ¾ inch diameter, 1¼ to 1½ inch. The speed of the piston under a pressure of 80 lb. of air per square inch is about 200 strokes per minute. For particulars and illustration of machine see Specification No. 1460, A.D. 1870. The inventor designed the machine to be held to its work by a single miner. For some time it was used at a mine near Eschweiller, and at one or two places in Westphalia; but the reactive impact of the machine on the shoulder of the workman, as well as the difficulty of keeping the tool in a determinate line, were disadvantages which could only be obviated by resorting to a mechanical mode of fixing it.

Rotary Drills.—The 'diamond drill' of LESCHOT, chiefly employed in America, consists of a hollow steel tube, in the ring-shaped base of which between twelve and eighteen diamonds are so fitted that each of them grinds a separate circle and leaves a cylindrical core to enter the tube. The rotary motion is effected by a small oscillating steam-engine, and the advance of a pair of screws by hydraulic pressure or by the dead weight of the rods. A jet of water, guided to the crown by the hollow rods, washes up the abraded stone. The process of sinking a hole consists in alternately boring, and, if necessary, securing the hole by iron tubes. As the steel part of the crown wears out quickly, the diamonds fall out frequently, which, however, can be easily perceived through the consequent vibration in the rods. The loose diamonds are brought up, after cleansing the hole with water, by a wax crown fitted in a steel ring. Other interruptions, arising from breakage in the rods, are rare. The rate of cost and time between different methods of drilling is shown in the following table:—

	For Depths to					
	394 Feet		787 Feet		1182 Feet	
	Time	Cost	Time	Cost	Time	Cost
Hand power	15	4	7	14		
Engine with stiff rods	7	4	6	5	3	3
Engine with rope	6	3	5	4	3	2
Diamond drill	2	2	2	2	1	1

A comparison between percussion drills and rotary diamond drills shows that the latter involve a greater expense of 1·75 per cent.

JORDAN'S *Patent Pneumatic Rock Drill*, which is driven by hand power, has only recently been brought under public notice, the patent being obtained in 1877. It is a machine of a different type from those previously described, inasmuch as its object is to apply hand labour in the most effective manner; and although very much has been done, and more will probably be done, by the use of power drilling machines, yet it appears by the demand that there is ample room for this new competition for public favour. Its obvious advantages are that it avoids the heavy outlay requisite for putting down a series of power-drilling plant, that it occupies but small space, requires no external connection with other and distant apparatus, and, therefore, being self-contained, may be moved from place to place, and at once used in any situation large enough to contain it.

The machine is made in various forms, to suit the different conditions under which it has to work (as shown in the illustrations); but the power cylinder and drill bar, together with all the parts requisite to give motion to the tools, are of precisely the same construction in each case.

The power cylinder of the standard patterns is 3½ inches diameter, and is fitted with a piston and tubular rod of steel, which works freely through long glands at top and bottom of the cylinder; the top of the cylinder is in two parts, and contains a cup-leather packing round the piston rod, which prevents any escape of the air contained in the cylinder.

The piston is slightly cupped in its upper surface, and is packed on this surface only with a disc of leather, which is of rather greater diameter than the cylinders, so that when it is pressed down into the cupped surface of the piston by a nut of proper form, which screws on the piston rod, its edges turn up against the cylinder and form a perfectly air-tight joint, with the least possible friction.

The top of the tubular piston-rod, above described, is fitted with a lifting block, which is made in three parts, two of which form its body, and one the sleeve which holds them together; it is made in this way in order to embrace the driving nut, the lower end of which revolves in it, as a thrust bearing. This nut is about 8 inches long, and is screwed through its entire length to fit the screwed portion of the steel drill-rod, which passes through the centre of the machine and carries the boring tool at its

2499

2500

lower end. The bar is screwed for about half its length, and the other or lower half is six sided, and fits through a cap of similar form on the bottom of the tubular piston-rod, so that it must turn with the piston, but may have independent longitudinal motion through the centre of it.

A somewhat similar arrangement admits of the long nut on the drill bar turning with or stopping on the bar, while it is always at liberty to travel through the bevel wheel which gears it with the feeding-handle.

The requisite motions are given to the drill-rod by two cams on the wheel shaft, and this is put in motion by men at the winch handles; it is found that from 150 to 180 blows per minute can readily be made, and that the rate of progress in every kind of rock is far greater than is possible by the usual methods of hand-drilling.

Having fully described the details of construction, a few words will suffice to make clear the action of the machine and its adjustments for work. If either the barrow or the tripod form of frame is in use, it is requisite to load it with the weights provided before commencing the work, but if the driving or column stand is used this is not requisite, because the machine is then securely fixed by a jack screw between the floor and back of the level, and with this or the barrow stand the drill bar may be adjusted to bore at any angle or in any direction.

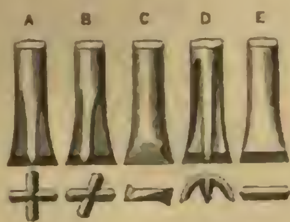
The machine having been properly fixed for drilling the required hole, and the tool having been brought in contact with the rock by turning the feed handle, the operation of drilling is started by the men at the winch handles turning them at the rate of about 80 revolutions per minute.

By revolving the wheel shaft the cams are brought into contact with the bottom of the lifting block, and it, together with the piston, feeding nut, and tool, is raised 4 inches, and then instantly released to strike the first blow; the force of this blow is dependent on the amount of compression to which the air confined between the piston and the cover of the cylinder is subject, which may be so adjusted as to give a pressure of 3 or 4 atmospheres on the area of the piston. The action of the cam on the lifting-block not only raises it through the length of stroke, but it also turns it a little, and

thus gives the tool a new position for the following blow; and if the feed nut is prevented from turning by its gear it also advances the drill bar through the piston rod and gives the required progressive motion to the tool. It is obvious that this progress of the drill must have a different rate for rocks of different hardness, and the means of regulating this is supplied by a friction clutch so arranged as to free the nut altogether, so that it turns at the same rate as the screw, in which case there is no progress of the tool, or the nut may be entirely stopped to secure sufficiently rapid feed for the softest rock, or by partial stoppage of the nut any intermediate rate of feed is readily attained.

(*g.*) *Rock-boring Tools.*—The method of fixing the tool to the end of the piston rod has received a large amount of attention from inventors. In 1866 JORDAN and DARLINGTON introduced a loop clip. Later a binding-ring came into use. Improvements on these methods are in progress, the object being to retain the tool with the axial line of the piston rod without resorting to rings, clips, or set screws. The form of the boring bit has also undergone radical changes, in some instances rendered necessary not for the purpose of drilling a round hole, but for neutralising the imperfect action of the turning gear employed. The following figures (2501) which will explain themselves, show 'bits' of various forms, the use of which is advocated by inventors of various rock drills.

2501



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Another form of tool for drilling centre or rupturing holes is shown in *fig.* 2502. The bit, Z-shaped, is of the same size as the ordinary drills; but it has also an enlarged part, armed with a Z-shaped cutting edge, 4 inches diameter. The length of the boring tools will depend upon the depth of the intended hole. At Ronchamp the longest hole was 9½ feet. At St. Gothard it is about 8 feet, while at Musconetcong Tunnel, New Jersey, the leading holes were usually 10 feet deep, the longest 14 feet.

In ordinary mine headings, and in the employment of comparatively small boring machines, the diameter of the boring steel may vary from ¾ inch to 1¼ inch. For rupturing the rock with No. 1 dynamite, or BRAIN'S No. 1 powder, the hole at bottom need not exceed 1 inch in diameter; but if second-class dynamite or compressed powder be employed, the hole in that case should be larger. In changing a boring tool, care must be taken that the cutting edge of the tool to follow is not wider than the intact cutting edge of the tool withdrawn. In the tool withdrawn it will be often found that the corners have been partly removed; the cutting edge of this tool is, therefore, that portion not rounded, but roughly parallel to the face of the hole. Many instances occurred in the rudimentary stage of machine boring, when machines were alleged to be useless—the fact having been that the cutting edge of the tool to follow was wider than that of the tool withdrawn, which tool, forced into a conical part of the hole, necessarily wedged itself fast, thereby stopping or retarding the working of the machine. As a common rule, the width of the different sets of boring tools at the points should vary from $\frac{1}{16}$ths to $\frac{1}{8}$ths of an inch from each other; or if the leading sets of tools are 1¼ inch wide at the point, the second or 'follower' set may be 1⅛ inch, and the third 1 inch wide. No rule can be strictly laid down for determining the time and power requisite to bore holes of varying diameter; but experience seems to show that if a hole 12 inches deep and 1 inch diameter takes 4 minutes, a hole 2 inches diameter and of like depth, bored with the same machine, and under the same conditions as to pressure of air and speed, will require 16 minutes. In other words, the machine and fluid pressure being the same, the time and power required to bore holes to a given depth are as the square of the diameter of the holes. It is, therefore, of considerable importance to keep the diameter of the shot hole as small as possible, and to supplement mechanical power by employing strong rupturing explosives.

Tunnel or Mine	Machines employed	Machines working together	Machines in Reserve for 1 in Use	Pressure Air per sq. in.	Form of Tool employed
Mont Cenis .	Sommeiller's . .	10	7	90	Z
St. Gothard .	Ferroux's, Dubois and François', MacKean's	6	6–8	90	X
Musconetcong	Ingersoll's . .	6	—	60–70	X
Maesteg .	Beaumont's . .	2	—	50	Semi-circular
Cwmbran .	MacKean's . .	2	1	70–80	Flat tool
Portskewet .	Geach's . .	2	2	60	X
Saarbrück .	Sachs' . . .	—	6	60	Flat tool
Ronchamp .	Dubois and François' . . .	4	1	67	X and Z
Blanzy . .	Darlington's . .	4	none	45	Flat tool
Minera .	„	1–2	„	50	„
Ballacorkish	„	1–2	„	45	„

(*h*.) *Water to Bore Holes*.—In boring shot holes, particularly deep ones, in argillaceous rock, it is necessary to remove the sludge as soon at it is formed. If this be not attended to, the rate of boring will materially lessen, and perhaps cease altogether, inasmuch as, instead of cutting or disintegrating the rock, the tool will operate on a cushion of clay or sandy material. An apparatus employed for the purpose of washing the stuff from the holes consists of a cylindrical vessel mounted on a trolly, and placed to the rear of the trolly carrying the frame on which the boring machines are mounted. *Figs*. 2503 and 2504 show this vessel in cross section and longitudinal elevation. A manhole is fitted with two pipes, one opening into the vessel, the other extending to the bottom of the vessel. Through the former compressed air enters, and exerts its pressure on the surface of the water; through the latter water is forced, and finds its exit at the end of a nozzle held at the mouth of the hole which is being drilled. To regulate the flow of water, a small cock is fixed just behind the nozzle. The rate of boring a dry and wet hole varies from 1 to 1·5—that is, it takes one-and-a-half times as long to bore a hole dry as to drill a hole with the assistance of water. A plentiful supply of water will not only materially quicken the rate of boring, but it will economise the use of power to a proportionate extent.

2503

2504

Cut or Sink.—In tunnelling or sinking shafts by means of rock-boring machinery it is necessary to conduct the operation in some special manner. When rock-boring machines were first introduced the miner insisted upon employing them as a mere substitute for the borer and mallet, and boring the holes so as 'to take advantage' of the ground. The result, however, proved unsatisfactory. Not only was the time required to get a position for the machine, to fix it, and to remove it excessive, but the work accomplished was not in proportion to its cost. The engineers of the Mont Cenis Tunnel were the first to recognise the fact that if power machines were to be successfully adopted, the hand method of doing the work must be discarded, and new conditions established. A given number—ten machines—were accordingly grouped together on a carriage, the natural rupturing lines of the rock disregarded, the holes

drilled more or less with the axial line of the heading, the machines and carriage withdrawn, the holes charged, the explosive fired, and the stuff removed.

These series of operations constituted an 'advance,' while in America, and in one or two English mines, it is known as a 'cut,' and in shafts as a 'sink.' The length of a cut, or depth of a sink, must depend upon many conditions inherent to the work itself, but if a level be wide, or the shaft large, longer cuts and deeper sinks can be made than if these works were small and confined.

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2506

(j.) *Boring the Holes.*—Two distinct systems of arranging the holes for blasting purposes in connection with rock-boring machinery have been introduced, viz.:—

(1) The 'circular cut,' which includes centre or rupturing holes, surrounded by shot holes more or less concentric with the rupturing holes, and angled so as to allow the explosive to remove a centre core, as well as the rock encircling this core (*fig.* 2505 and *fig.* 2506).

(2) The 'square cut,' in which the shot holes are mostly placed parallel to, or at right angles to, the side of a level or shaft, the holes in each case angled so as to admit of the removal of a middle wedge, as well as the rock on each side of this middle wedge (*fig.* 2507 and 2508).

(1) *Circular-cut System.*—*Fig.* 2505 and *fig.* 2506 illustrate the circular-cut system, first employed in driving the Mont Cenis Tunnel, and which is followed at the Marihaye Colliery, Belgium. The centre hole o is drilled by means of a double Z-shaped bit (*fig.* 2502), the point of which is 1¼ in. wide, followed by a wing-bit, 4 in. diameter. The centre hole, 4 in. diameter, is surrounded by four other holes, 1¼ in. diameter. These small holes are charged with explosive material, and blasted so as to rupture and crush in the rock on the centre hole referred to. Around these central holes other holes are drilled, and angled so as to enable the explosive to remove the rock in the form of concentric 'cuts.' Two of these holes, c c, are 3¼ ft. deep, the remainder 5 feet deep. At Marihaye the levels, 7¼ ft. high by 7¼ ft. wide, are each perforated with 24 or 26 holes. At Ballacorkish, where the shaft is 10½ ft. diameter, the centre or rupturing holes are dispensed with. The inner circle includes 4 holes angled towards the centre, the second circle comprises 8 holes, the third or outer circle 12 holes, which are angled as shown in *fig.* 2494.

(2) *Square-cut System.*—At Musconetcong the tunnel heading, 20 ft. wide by 8 ft. high, gave a net area of about 175 square feet. This face was perforated with 36 holes by means of six powerful boring machines, each cylinder 5 in. diameter. The area of the face apportioned to each machine was 29 square feet. The number and depth of the holes to obtain a cut of 10 ft., or an actual lineal advance of 9 ft., were:—

Cut	12 holes,	each 10½ ft. deep.
First square up	8 ,,	,, 12 ,,
Second ,, ...	8 ,,	,, 12 ,,
Third ,, ...	6 ,,	,, 12 ,,
Four roof-holes	2 ,,	,, { 10 ,,
	2 ,,	,, { 8 ,,
Total . . .	36	

The aggregate depth of the 36 holes was 408 lineal feet; number of square feet of heading to one hole about 4 8-10ths. The following is Mr. Drinker's description of driving by the square-cut system:—The method of blasting by cuts is based on the extraordinary force developed by a comparatively small bulk of explosive matter. It consists in first blasting out an entering wedge or core, about 10 ft. deep at the centre, and subsequently squaring up the sides by several rounds. To do this 12 holes are first drilled by six machines, three on a side, the holes placed as shown in *fig.* 2507.

and marked c, A being the floor of the heading. Then 12 holes are drilled, two and two, six on a side, with from 1½ to 2¾ in. 'bits,' the two sets being started about 9 ft. apart, and at such an angle (see *fig.* 2508) as to meet or cross at the bottom, the largest bit being put in first. The holes are then charged with about 25 lb. No. 1 and 50 lb. No. 2 dynamite, and fired simultaneously by electricity. No. 1 is only used for cuts, inasmuch as in them a quick strong powder compressed in a small bulk at the bottom of the holes is required where the greater resistance will be found, while the No. 2 added serves in filling up the holes, so starting the sides of the cut as the apex moves—the cut, A, being out, a second round of holes is started for the first squaring up, as shown by the numbers 1 1 1 1, *figs.* 2507 and 2508.

2507

2508

In these and the subsequent rounds, 2 2 2 2, and 3 3 3, the resistance is pretty equally distributed along the whole length of the holes; and as it is not so great as in the cut, No. 2 is used, as in it the nitro-glycerine being mixed with a larger proportion of absorbent matter, the force is thereby distributed over a greater space. In the first and second squaring up rounds from 50 to 60 lb. of No. 2 are charged, and in the third from 80 to 90 lb., the holes getting stronger as the arch falls at the side. There are generally also one or two additional roof-holes in the third round that are not shown in the figure, their position being variable according to the lay of the rock. The top holes in the first round are also designed to bring down the roof not shaken by the cut, and are, therefore, strongly angled towards the centre, and always drilled from 12 to 14 ft. deep. The plan, *fig.* 2508, shows the cut holes; 4, 5, and 6, the squaring up rounds.

As to the relative depth, the holes of the first squaring round are always drilled a foot or more deeper than the cut holes; and when blasted they generally bring out a foot additional of shaken rock at the apex of the cut.

At Minera Mines, North Wales, the square-cut system is advantageously followed in driving levels in short grain and jointy limestone. The face of a level for running two DARLINGTON boring machines 6½ ft. wide by 7 ft. high is perforated with 26 or 28 holes, each about 3 ft. deep—viz. centre cut, 8 holes; first square-up, 8 holes; second square-up and roofing holes, 8 to 10 holes.

BRAIN'S *Radial System.*—This system, devised by Mr. W. BLANCH BRAIN, of St. Annals, Cinderford, was introduced about three years ago at the Drybrook Iron Mines, in the Forest of Dean. The main object of the inventor was to perforate the face of a level without once shifting the stretcher bar when placed at its proper height. M. ANDRÉ, in his work on coal mining, thus notices the radial system:—'The fundamental principle which constitutes its distinctive character is to make the holes of a series to radiate from a fixed point. The object of this radiation is twofold—to utilise the face of the heading as an unsupported side, and to reduce to a minimum the time consumed in changing the position of the stretcher bar. It will be obvious on reflection that if these ends are attained without incurring a compensating loss, the merits of the system are beyond question, since their attainment leads to rapidity of progress, which is the main purpose of machine labour. It is evident that if the holes are made to radiate from a fixed point, and the horizontal position be avoided, none of them can be perpendicular to the face of the heading, and, consequently, the lines of fracture from each charge tend to reach this face. A consequence of this fact is that no unkeying of the face is necessary, since each shot tends to blow outwards. Let it be assumed that the drift to be driven is 6 ft. 8 in. in height. The width in this case is immaterial to the operation of the system. The stretcher bar, which is to serve as a support to the machine, is fixed at a certain height from the floor, and at a certain distance from the face, as shown in *fig.* 2509. The height of the bar above the floor, with slight modifications to suit existing conditions, will be the same in all cases; but the distance of the bar from the face will be determined by the length of the machine, or at least by the distance from the centre of the clamp to the end of the piston rod, into which the bit is fixed. It is obviously desirable to reduce the distance between the face of the heading and the stretcher bar as much as possible, since the angle of the holes will rapidly increase as the distance is diminished

From the figure it will be observed that the stretcher bar is fixed 1 ft. 8 in. from top, 5 ft. from bottom, and 2 ft. 4 in. from the face. The first and second series of holes are 3 ft. 1 in. deep; the third, 3¼ ft. deep; the fourth, 3¾ ft.; and the fifth, 1¼ ft. deep. The bottom or lifting holes are 3 ft. long.

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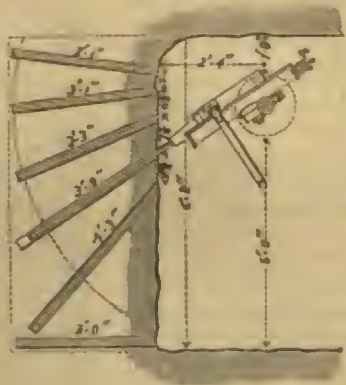


In a heading 6 ft. 8 in. by 6 ft. 8 in., giving an area of 44 square feet, 29 holes were bored, representing a total lineal length of 60 ft. 8 in. As the cut or advance was about 3 ft., it follows that each hole removed nearly 7 cubic feet of rock.

Places	Diameter of Shot Holes at Bottom in Inches	Average Depth of Shot Holes in Inches	Area of Level or Shaft in Square Feet	No. of Shot Holes made in Face for one Advance	No. of Boring Machines employed	No. of Square Feet of Face to one Borer
Mont Cenis	1⅝	30–48	83	55–65	10	8 3/10
Hoosac Tunnel	—	108	216	40	10	21 6/10
St. Gothard	1 3/16	42–84	72	26	6	12
Severn Tunnel	1½	24–30	64	12–15	2	32
Altenberg Mines	1	20–36	52½	10–12	2	26¼
Persberg Mines	1⅛	24	72	—	1	72
Salzbach	1	21–24	175¼	10	1	175¼
Anzin	1⅜	60–72	57	19	4	14¼
Marie Colliery	1¼	72	34	30	4	8½
Pierre Denis	1¼	72	31	—	4	7¾
Pierre Denis	1¼	72	52½	—	4	13
Stahlberg	1¼	24–30	40	8	1	40
Gunlay Colliery	1¼	30–40	64	—	1	64
Drybrook Iron Mine	1¼	37–51	40	34	1	40
Sir Francis Level	1¼	48–60	35	30	1	35
Minera Shaft	1½	30–36	56¾	26	2	28⅜
Johann Colliery	1¼	58	228	—	6	38
Minera Level	1½	30–36	46	24–26	1	46
Ballacorkish	1¼	40–60	86½	22–24	2	43¼
Carnbrea	1⅜	36	72	—	4	18
South Crofty	1¼	24	—	—	1	—
Cwmbran	1¼	30–36	70	10	2	35
Dolcoath	1½	28	44	20	1	44

(*k*) *Charging and Blasting Shot Holes.*—In the use of rock-boring machinery it is essential to the quick despatch of work that no time be unavoidably lost in the charging and blasting operation. At Marihaye ordinary powder is employed in the form of compressed cylinders of the diameter of the shot hole, each cylinder having a hole at the bottom and a recess in the side for receiving a piece of 'Bickford's safety fuse.'

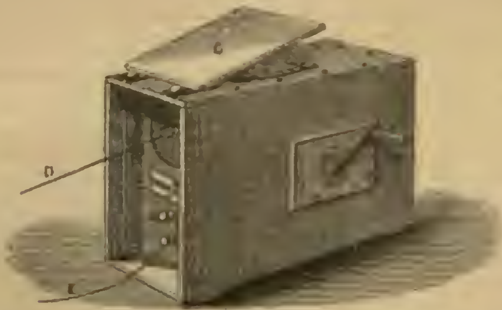
For blasting purposes, particularly in hard, compact and wet ground, dynamite, lithofracteur, or BRAIN'S powder are each to be highly recommended, since either can be detonated, its explosive power instantly developed, tamping almost dispensed with, and from the plastic nature of the material it can be easily pressed so as to fill the bottom part of the hole, in which condition it will on explosion exert its greatest rupturing force on the rock. Moreover, the charges of the explosive may be made sufficiently great to reduce the rock into small and convenient fragments for ready and cheap removal. At Ronchamp, in France, powder and dynamite in the same hole have been employed with excellent effect, the powder prolonging, as it were, the time of the explosion, and exerting its force on the rock weakened by the quicker rending force of the dynamite. At Musconetcong the strongest dynamite, containing 75 per cent. of nitro-glycerine, was employed for unkeying the heading, and dynamite of second quality for rending the side holes. Naturally, in the use of explosives singly or together, the greatest care is necessary on the part of the workmen to distribute and vary the charge, so that when fired or detonated the rock shall be ruptured for removal without incurring any undue waste of the explosive. When tamping is required, clay or dry sand cartridges should be prepared. The strongest kind of tamping is afforded by dried clay, rolled when damp into the form of a sausage, from three to four inches in length, and of the full diameter of the bore hole. When the hole is ready for tamping, a handful of fine dry sand should be thrown upon the charge, a clay roll then introduced, and pressed, without blows, so as to fill the hole completely; a second roll is to be added, and pressed in the same way until the hole is tamped. If the charge is to be detonated, a slight modification of the tamping process may be made. Immediately above the charge, place a wad of hay or a handful of dry and very fine sand, or fine clay; upon this sand or clay, force with a wooden rammer, a plastic clay roll from three to four inches long, and of the same diameter as the bore hole; above this roll fill the hole with fine sand. The order of firing the holes should be determined at the time of charging and tamping the holes; the lines of stratification or of least resistance should also be carefully observed, and such holes selected for the first volley as are most likely to rupture and unkey the rock to the desired depth, and at the same time secure the best results when the second set of shot holes is fired. When the shot holes are to be fired in successive series concentric with the centre holes, or in line with the centre cut, and by means of safety fuse, the length of the latter can be regulated so as to effect the discharge of certain holes earlier than that of other holes; and if the fuses are brought together, the ignition of the various ends may be effected at one and the same time. In various places electric blasting is resorted to, and for this frictional and other fuse-igniting machines have been constructed.

To be successful in the application of electricity to the firing of shot holes, it is absolutely necessary that the machines, the firing cable, the connecting wires, and fuses shall be reliable, and that, whether the fuses are placed in single or divided circuit, the number shall not be greater than can be certainly and simultaneously fired. In the engine shaft at Ballacorkish (*fig.* 2494) electric blasting is employed, ten or twelve holes are charged with dynamite cartridges fitted with BRAIN'S electric fuses. These fuses are connected together in single circuit, and fired either by BRAIN'S or BORNHARDT'S frictional machines. Two firings are sufficient to remove the 'bottom' of the shaft, 10½ feet in diameter, to a depth of 4 feet, the operation of charging and blasting being completed in from 2 to 2½ hours. At Marihaye (*fig.* 2505) the first shots are fired in the deeper holes, *a a*, situated near the large central hole, and the rock broken in such a manner as to leave a cavity, *b b*. The smaller holes, *c c*, are then charged to blow down the portion at the front of the cavity which may have remained untouched; but it often happens that these small holes prove unnecessary, and that the same effect is produced to their full depth by the first shot. The process is continued by means of the holes *d d*, situated on a horizontal line passing through the central hole in such a manner as to form an excavation, as if 'hewn' across the face of the rock to be cut away. Afterwards the upper holes are fired, and the operation is finished in those near the floor. The blowing is performed in volleys of four or five charges at a time, the stuff being loaded up and removed from time to time. To loosen the rock it is necessary that several holes should be fired simultaneously, especially in the hard grit.

BORNHARDT'S *Frictional Machine*.—This machine (*fig.* 2510) is composed of a single-plate wheel of ebonite, which can be rotated rapidly by turning the handle either way. The top part of the ebonite wheel within the box is in contact with a rubber formed of catskin. It is the friction of this skin on the surface of the wheel which excites the electricity. This electricity is collected and stored in a Leyden jar. Metal rings project through the front end of the machine. To these rings the ends of the wires forming the circuit are attached when everything is prepared for

firing. A is the firing knob by which the discharge is made. The knob being pressed, allows the charge stored in the Leyden jar to pass along the leading wire D to the

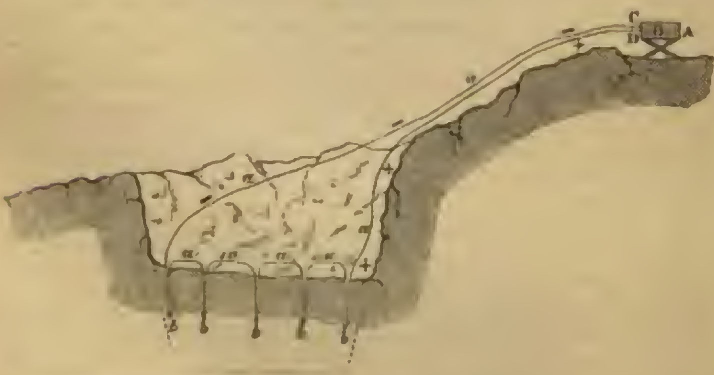
2510



fuses, which in turn fire the explosive. The illustration (*fig.* 2511) clearly shows an electrical firing arrangement. A, stand for electrical machine; B, electric machine; C, leading wire or cable; D, return cable; *a a a a*, wires connecting the fuses; *b b b b b*, fuses attached to the explosive cartridges. On pressing the knob A (*fig.* 2510) the electric charge passes from C (*fig.* 2511) along the leading wire *a a* down to the first cartridge *b*, up the connecting wire *a*, down the second cartridge *b*, and up the second connecting wire *a*, continuing its course in this way, firing the cartridges and returning to the machine by the return cable *a* D.

BRAIN's *Machine*.—This frictional machine is contained in a neat box of small dimensions and of light weight; the condenser and other parts are well protected against access of moisture. To fire 1 hole the crank is turned 5 times; 2 to 5 holes, 10 times; 6 to 10 holes, 15 times; 11 to 20 holes, 25 times.

2511

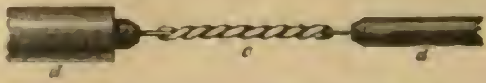


SIEMENS' *Dynamo-Electric Mine-Exploder*.—This apparatus gives, as the result of the expenditure of mechanical power, magnetism and electricity. It consists of an ordinary SIEMENS' armature, which is caused by the turning of a handle to revolve between the poles of an electro-magnet. The coils of the electro-magnet are in circuit with the wire of the armature, and the residual magnetism of the electro-magnet cores excites at first weak currents, which pass into the electro-magnet coils, increasing the magnetism of the core, and inducing still stronger currents in the armature wire to the limit of magnetic saturation of the iron cores of the electro-magnets. By the automatic action of the machine this powerful current is sent into the wire or cable leading to the fuse.

Conducting Wires, Insulators, and Supports.—The wires leading from the machine (*fig.* 2510) to the locality of the shot holes may be either of copper or iron; the former is the better conducting medium, and is the most commonly employed. The sectional

area of the wire is of great importance in its conducting power; the resistance to the passage of the electric fluid is found to *vary inversely* as the sectional area, and hence it is important to give the leading or circuit wires a sufficient diameter. A cable suitable for underground purposes is formed of an insulated core (*fig.* 2515), composed of three strands of copper wire, No. 20 gauge, thickly insulated with india-rubber *h*, and tape *g*, the whole covered with plaited and tarred hemp or twisted wire, not

2512


2513


2514


2515


shown in the sketch, to the size of a rope ⅝ths or ¾ths of an inch diameter. The insulators and supports for such cable may be of the simplest character. Near the roof of a level, holes may be made 15 or 20 ft. apart, and into these holes pieces of wood driven; the cable can then be passed through a hole made in each piece of timber, then strained, and wedged tight. To lengthen this cable it is only necessary to expose about 1½ inch of the wires, to scrape these wires bright, then twist them tightly together, *c* (*fig.* 2513), and to cover the exposed part *c* by a piece of tubular india-rubber *e*, tied to the insulated portion of the core, *f* (*fig.* 2514). To connect the fuses together small fine copper or iron wire, *a* (*fig.* 2512), is employed. The ends of this wire should be scraped bright and twisted together, as shown at *b*.

Electric Fuses.—An electric fuse consists of a charge of explosive compound capable of being ignited by an electric current or spark. The fuse itself is practically either an interruption of the cable circuit or a great increase in its resistance at some point by the interposition of a badly conducting substance; the consequent action is that either an electric spark passes between the interrupted portions of the conductor, or the piece of bad conductor is highly heated, causing ignition of the explosive substance contained in the fuse.

As there are two classes of exploders, so there are also two kinds of fuses –

(*a*) *Tension Fuses*, and

(*b*) *Quantity Fuses.*

2516


The tension fuses are also called 'spark' fuses, 'high-tension' or 'chemical fuses,' these terms arising from the nature of the electricity employed to fire the fuse or from the nature of the fuse itself. The *quantity fuses* are also called 'platinum-wire' fuses. Some quantity fuses are, however, chemical fuses, the bad conductor being a chemical composition; hence the term 'low-tension chemical' fuses. From the nature of the electric currents employed to fire them, 'quantity' fuses are also termed 'low-tension' fuses, whether they contain platinum wire, steel wire, or merely a chemical composition.

Fig. 2516 shows an ordinary tension fuse—*a*, plug of gutta-percha mastic, wood, or paper; *m*, a cap of paper, but usually of metal; *k*, the fulminate. The firing composition is set immediately under the plug surrounding the bottom of the wire. This wire is divided at the bottom. In firing the detonator by a frictional machine (*fig.* 2510), the electric spark passes down one side of the wire, leaps from the point through the firing composition, igniting it in its path, to the other point, ascends the wire to ignite other fuses in a like manner, to be dispersed or to return to the machine (*fig.* 2511).

Abel's Fuse.—This fuse is well known for the purpose of submarine blasting, but it is somewhat too costly for use in ordinary mining operations. The composition of the explosive mixture is—subphosphide of copper 10 parts, subsulphide of copper 45 parts, and chlorate of potash 15 parts. The fuse head is of wood.

MOWBRAY'S *Fuse*.—The firing compound of this fuse, which was employed in the Hoosac Tunnel, consists of sulphide of copper 2 parts, and chlorate of potash 3 parts, the two intimately mixed together. The fuse head is partly of gutta-percha.

BRAIN'S *Fuse*.—This fuse is characterised by the neatness of its appearance and for the excellence of the firing composition. It is also carefully and well insulated, and while it can be handled with the greatest safety it is exceedingly sensitive. At Ballacorkish, at the bottom of the shaft (*fig.* 2494), with BRAIN'S firing machine from 12 to 15 fuses are fired simultaneously.

ANDRE'S *Fuses*.—These are of two kinds, tension and quantity fuses. The firing composition is not publicly known. The fuse consists of a detonator, a firing composition, a mastic plug, and insulated wires.

BORNHARDT'S *Fuses*.—These fuses have a particularly neat appearance, are very sensitive, and well insulated. BORNHARDT has also contrived a fuse for marine blasting purposes, alleged to be reliable under a pressure of 20 atmospheres.

ARWIG'S *Fuse*.—This fuse consists of a thin lath of wood $\frac{3}{8}$ths of an inch wide by $\frac{1}{8}$th of an inch thick, fitted at one end with a turned tube containing the detonating charge, into which the wires are led. These wires are lodged in grooves formed in the narrow faces of the stick.

Electricity as a power for blasting shot holes was employed in the year 1850 at the Abercarn Colliery, South Wales, an excellent and reliable fuse having been contrived for the work by Mr. ROBERT HUNT, F.R.S. The value of simultaneous blasting, however, is only now becoming fully appreciated. In connection with the use of rock-boring machinery it will become a necessity. Some of its special advantages are—

(1) A simultaneous discharge of several holes brings the whole of the eruptive force into action at one and the same moment, and is thereby capable of removing rock which would more or less remain fast if the shots acted independently of each other.

(2) A great saving of time is effected by the use of electric fuses and resorting to simultaneous blasting, since, if the forebreast of a level, or bottom of a shaft, is perforated with twenty or thirty shot-holes, and this number of fuses can be fired in one or two operations, it follows that the delay consequent on shifting from the place, and on clearing the gases or 'smoke,' is reduced to one, instead of representing several units of time.

(3) This means of firing affords security from accidental explosion; not only are the charges fired at the exact moment required, when it has been clearly ascertained that all the workmen are under shelter, but the danger from the use of matches or 'snuffs' is altogether avoided.

Table of Explosives, Fuses, and Tamping.

	Explosives employed	Fuse	Length of Safety or Electric Fuse	Materials employed for Tamping Shot Holes
Mont Cenis	Compressed powder (one inch diameter)	Safety fuse	96 in.	Dry earth in cartridges
St. Gothard, Göschenen	Dynamite in cartridges (of 3 to 4 ozs. each)	Safety fuse with a detonator	60–72 in.	Sand in paper cartridges
St. Gothard, Airolo	Dynamite in cartridges (of 3 to 4 ozs. each)	"	"	"
Portskewet	Dynamite	"	24–28 in.	Water
Musconetcong	Dynamite (No. 1 and 2 quality)	Electric fuse	11–13 ft.	"
Festiniog	Dynamite	"	40–48 in.	"
Altenberg	Ordinary powder	Safety fuse and detonator	40 in.	"
Altenwald	" "	Electric fuse	30 in.	"
Marihaye	Compressed powder cartridges (5 ozs. each)	Safety fuse	60 in.	Dry clay
Ronchamp	Ordinary powder and dynamite	Safety fuse and detonator	90–96 in.	Dry clay in paper cartridges
Anzin	Dynamite	"	50–60 in.	Clay
Mineca	"	Electric and safety fuse	30–35 in.	Water

	Explosives employed	Fuse	Length of Safety or Electric Fuse	Materials employed for Tamping Shot Holes
Dolcoath	Dynamite	Safety fuse and detonator	24–25 in.	Water
Carn Brea	,,	,,	—	,,
Ballacorkish	,,	Electric fuse	60 in.	,,
Friedrichsegen	,,	,,	30 in.	Clay
Drybrook Iron Mines	,,	,,	40–50 in.	,,
Stahlberg	,,	,,	24–30 in.	,,
Corrèze, France	,,	,,	40–44 in.	Water
Sir Francis Level	,,	Fuse and detonator	48 in.	,,

(*l.*) *Removal of Stuff.*—After charging and blasting a set of holes, it will in many cases be found desirable to exhaust the gases which have resulted from the decomposition of the explosion. At St. Gothard a powerful 'duck' machine is employed, the exhaust pipes being of large dimensions. At Cwmbran, South Wales, a large fan is in use, the exhaust canal being of wood, inside width 12 in., depth 30 in. At Portskewet, dimensions of heading 8 ft. by 8 ft.; the air pipes, 12 ft. long, are of sheet zinc 12 in. diameter. At Ballacorkish the gases are expelled by passing air from the receiver into the air pipes, the outlet of which is close to the bottom of the shaft. As soon as the explosive gases are removed, the stuff should be withdrawn as quickly as possible. In the case of a shaft, the kibble or bucket should descend to the bottom, and its capacity, together with the speed of drawing, ought to bear some general relation to the work to be done; in that of a level, the waggon ways should be arranged for quick removal of the stuff, for introducing the boring tackle, and for recommencing the boring almost immediately after the blasting operation has terminated. In a wide heading, such as that carried in forming the Musconetcong Tunnel (see *fig.* 2507), three railways may be laid, two for the boring machines and the central one for the removal of the stuff. In ordinary mine levels, the most that can be done is to lay a single railway, to form sidings in long levels, to cast the stuff each side of the rails close to the forebreast after a blast, so as to introduce the boring frame and to bring the forwarding waggon immediately to its rear.

Time of Operations.—The time incurred in the triple operation of (1) boring, (2) charging and blasting the holes, (3) removing the stuff, will depend upon a variety of circumstances, partly incident to the work itself and partly under the control of the contractor or workmen. (1) *Boring.*—The duration of the boring operation will be in proportion to the number of machines employed, their reliability for the work, the number and depth of the holes, the number of boring tools to be changed, the facility which exists for changing the tools quickly, and the ease with which the machines may be shifted from one point to another. (2) *Charging and Blasting.*—To minimise the time the cartridges and fuses should be prepared beforehand, and the shot holes, if at the bottom of a shaft, plugged when the tools are withdrawn, so that the cartridge and fuses may be dropped to the bottom of the holes without clearing them for that purpose. The maximum number of holes should always be selected for simultaneous or volley firing, in order to lessen the number of firing operations. (3) *Removal of Stuff.*—This should be done quickly, and by means already suggested under this heading (*l.*). The time required for making a 'cut' or 'sink' in some of the works already executed by means of rock-boring machines is approximately shown in the following table:—

	Boring Shot Holes	Tamping, Charging, and Blasting	Removal of Stuff	Total Time of Cut or Sink	Proportion of Time of Boring to Total Time of Operation
	Hours	Minutes	Minutes	Hours	
Mont Cenis	6–8	75–105	60–120	8–12	0·74
Altenberg	6	6 hours			0·25
Mariboye	5–7	90–120	90–120	8–11	0·45–0·65
Ronchamp	8	480	480	24	0·33
Anzin	3–4	90–120	120	5	0·45
St. Gothard, Göschenen	3–4	30–45	150	5–12	0·60–0·65

	Boring Shot Holes	Tamping, Charging, and Blasting	Removal of Stuff	Total Time of Cut or Sink	Proportion of Time of Boring to Total Time of Operation
	Hours	Minutes	Minutes	Hours	
St. Gothard, Airolo .	6–8	120	150	10–13	0·60
Ballacorkish . .	7	140	23 3/10 hours	31	0·22
Cwmbran . .	3½	30	120–180	7	0·50
Porthkawl . .	3	60	Stuff removed during subsequent boring shift	4	0·35
Dolcoath . . .	3	60	"	10	0·32
Minera . . .	9	240	600	24	0·37

Relative Cost and Progress of Work.—Pernolet, after an exhaustive inquiry into the conduct of different works, found that the saving of money arising from the use of rock-boring machinery varied from 7*s.* 1*d.* to 74*s.* 7*d.* per lineal yard, that the rate of progress was to a certain extent in proportion to the number of machines employed, together with the relative hardness of the rocks. Compared with hand labour alone, the speed by means of machinery was from three to twelve times greater. At Marihaye the hand cost in the slaty rock was 30*s.* 4*d.*, the machine cost 20*s.*, per yard. In the grit rock the hand cost amounted to 60*s.* 8*d.*, the machine cost to 52*s.*, per yard; the machine speed was about three times greater than that of hand labour.

The deep adit level known as Joseph II.'s Adit, at Schemnitz, which was commenced in 1782, is intended to be of a total length of 17,827 yards, or about 1,420 yards longer than the St. Gothard Tunnel. Of this length 15,320 yards have been driven by hand labour during the course of ninety-two years, leaving two sections unfinished, one of which is 1,504 yards, and the other 1,000 yards long. In the latter section the use of machinery was commenced experimentally in the year 1873, and was continued at intervals during the following year. In the first series of experiments one machine of Sachs' construction was used, the average depth of the bore holes being 1·8 foot, which were charged with dynamite and fired by means of fuse. The average daily advance of the level, which was 8·5 feet high and 6·9 feet broad, was 2·1 feet. In the second series two machines were used, and the charges were fired by electricity; the result was a daily advance of 3·28 feet, the rock being, as in the first series, a moderately hard trachyte (rhyolite). In the third series two machines on an improved frame were used, the holes being 2·3 feet deep; the advance was 9·8 inches per day in greenstone. In the fourth series, when the men were becoming better acquainted with the use of the machines, the average length driven per day was 4·2 feet. Great difficulty was at times experienced in the use of the electrical apparatus from misfires, especially when the air in the level was highly charged with moisture. It was found most convenient to have two machines, which were used alternately, and only taken into the mine when the holes were loaded and ready for firing. It was also considered desirable not to fire more than twelve holes at one time.

In order to obtain a basis for comparison with hand labour, a fifth series of experiments was made by twelve selected miners, working four at a time, eight-hour shifts, under continuous supervision; when it was found that twelve men in four days advanced the level 11·5 feet, equal to 2·9 feet per day, thus producing somewhat less effect than a single machine.

The most advantageous method of arranging the bore holes is considered to be in four vertical lines about equal distances apart, but having the holes in the centre rows somewhat closer together than those at the side, there being six in each of the former series and only four in the latter. By this arrangement, a uniform depth of 2·3 feet being adopted as a standard, the stand only required to be fixed twice for each set of twenty holes. The two central rows are loaded to a third of their depth with dynamite and fired first, making a deep notch in the face. This increases the effect of the side holes, which are fired subsequently with a somewhat smaller charge.

At the St. Gothard Tunnel in 1873 the drift at the Göschenen end was advanced, by six of François and Dubois' machines, 6·2 feet per day, or 12·2 inches per machine; while at Schemnitz at the end of 1874 two of Sachs' machines drove at the rate of 3·4 feet per day, or 20·4 inches per machine. In the former cases 62·0 per cent. of the total depth of holes bored proved effective, while in the latter the proportion was 75·2 per cent., a result attributed to the electric ignition and the method of firing adopted. The cross sections of the two levels are, at St. Gothard 72 square feet, and at Schemnitz 58 square feet.

In a level 560 fathoms long, driven in Yorkshire by Sir GEORGE WILLIAM DENYS, the hand price was reckoned at 12*l.* per running fathom; the mechanical cost, including 27*s.* for dynamite, caps, and fuse, was 5*l.* 10*s.* per lineal fathom. In this instance the compressing machinery was driven by water power, for which there was no current charge. The machine speed was from three to four times greater than that of hand labour. At Dolcoath the machine cost is alleged to be 25 per cent. less than the hand cost, and the speed three or four times greater. At Carn Brea, with four powerful boring machines in a single heading, with every necessary appliance, an abundance of skilled labour, and a thorough organisation of the work, the machine cost is stated to be as high as the hand cost, but the rate of driving eight to ten times greater. At Minera, with one DARLINGTON boring machine in a level 6½ feet by 7 feet, the cost of driving is one-third less, and the rate fourfold greater, than is practicable by hand labour. At Ballacorkish the machine cost is 65 per cent. less than hand cost; the progress in an engine-shaft partially blocked with pumps and a drawing way is from five to six times faster than is practicable by means of hand labour alone. At Foxdale Mines, in the Isle of Man, where rock-boring machines have been recently introduced for the purpose of sinking a shaft, the cost of the work is found to be much less than that of hand labour, and the speed also much greater. At Friedrichsegen, Prussia, the cost of driving a level by hand was 10*l.* 10*s.*, and by machinery 6*l.* 8*s.* 6*d.* per yard. In executing mining work it is necessary to pay strict regard to cost, as well as to speed. Special cases may well justify a heavy current expenditure in order to realise a particular object, but in the ordinary conduct of mining operations an extravagant high-pressure system of working cannot prevail throughout a series of years without tending to neutralise the economic advantages which ought to be derived from the employment of rock-boring machinery.

Boring Machine Accounts.—In working ground by means of boring machinery it is desirable to record particulars connected with the various operations. At the Rushen Mines, Isle of Man, where important results have been obtained by Captain JOHN BARRELL with the DARLINGTON machines, the following form is employed:—

RUSHEN MINE.—MEMORANDA RELATING TO ROCK-BORING OPERATIONS.

Nature of Work. *Sectional Dimensions.*

Date, viz. from *of* *, to* *of* , 187 .

(*a.*) BORING HOLES.

No. of hours boring . . .	Aggregate number of feet bored
Average depth of holes . .	No. of bits blunted . . .
No. of machines employed .	Duration of hindrances . .
No. of holes bored . . .	

(*b.*) CHARGING AND BLASTING HOLES.

No. of charges and blasts . .	Time occupied in charging .
Time occupied in blasting .	No. of electric fuses used . .
Weight of dynamite consumed .	Duration of hindrances . .
No. of fuses misfired . . .	

(*c.*) REMOVING STUFF.

No. of kibbles drawn . .	Time occupied in drawing . .
Estimated weight of stuff drawn	Duration of hindrances . .
Average weight of kibble . .	

	Fathoms	Feet	Inches
Sunk or driven at end of previous week . .			
Sunk or driven during the week			
Total depth sunk or driven . . .			
Total number of 'cuts' or 'sinks' made			
Total number of hours worked			
Lowering pumps			
Total number of hours hindered			
Proportion of time hindered to total time worked			
Weight of coal consumed driving compressor (estimated) . .			

Sundry Places where Rock-boring Machines have been successfully employed.

	No. of Borers simultaneously employed	No. of Hands employed with Machines	No. of Cuts or Sinks made per 24 Hours	No. of Cuts or Sinks made per Week	No. of Holes made for one Fathom of Advance Cut or Sink	Total Depth of Holes made for one Fathom of Cut or Sink	Direction of Holes
Tunnels.						Feet	
1. Mont Cenis	10	24	2–3	14–21	12–16	428	A centre hole and a series of concentric holes.
2. St. Gothard, Göschenen	6	18	3	21	32	187	Three central holes, 10 holes on the perimeter forming the contour lines of the level, and 4–6 holes between the centre and outer holes.
3. St. Gothard, Airolo	6	20	2–3	14–21	48	187	
4. Severn tunnel	2	12	4–6	24–30	48–72	100–180	
Mines and Collieries.							
5. Altenberg zinc mines	1	6	1	6	58	100	Bored to take advantage of the bedding and cleavage of rock.
6. Persberg	1	—	—	—	—	—	
7. Altenwald	1	4	3	18	300	410	Generally diverging from the axis of the shaft.
8. Audin, St. Leonard's	1	2	3	18	60	91	Bored according to the circumstances of the rock.
	4	4	3	18	99	210	Generally towards the centre of the level, but varied so as to take advantage of the rock.
9. Marihaye	4	5	1½–2	0–12	48	100	
10. Marie Colliery	4	5	1½–2	0–12	30	104	More or less on a line with the centre of the level.
11. Pierre Denis	4	3	1½–2	0–12	33	108	
12. Stahlberg	1	2	3 times that of hand labour	—	—	—	Bored to take advantage of the bedding and cleavage of the rock.
13. Gonley	1	—	2–3 times that of hand labour	—	—	—	
14. Drybrook	3	3		—	29	140	Brain's system; holes bored from a transverse bar with one firing, and to blast outwards.
15. Sir Francis Level	1						
16. Johann Colliery	6						
17. Friedrichssegen, Prussia	4	4	3 times that of hand labour	—	42	165	More or less in a line with the centre of the level.
18. Ronchamp	—	5	—	6	20	150	Almost parallel to the centre of the level.
19. Mieres (shaft)	1–2	3	3–4 times that of hand labour	3	30–50	180	More or less around the centre of the shaft.
20. Marsberg	2	—	—	—	—	—	Variable.
21. Carnbrea	2	5	3	23–24	31	66	Bored towards centre and sides of forebreast.
22. Ballacorkish (shaft)	2	9	—	3	50	130	More or less concentric with the centre of the shaft.
23. Minera (level)	1	8	—	6	39	120	More or less in line with the centre of the level.
24. Carew (shaft)	1	12	—	—	40–45	100–150	Bored as seemed best for effecting removal of ground.
25. Festiniog	4	—	—	—	60–65	130–160	
26. Tisbouth	1	12	—	—	60–80	100–180	

By way of summary it may be observed that the objects to be kept in view in the employment of rock-boring machinery are—the attainment of a high rate of speed at a moderate cost. To realise these two distinct results the tackle must be efficient, the work well organised, the roadways of proper dimensions for the removal of the stuff, the hauling arrangements satisfactory, the contingencies incident to the work anticipated, and hindrances avoided. The use of boring machines will tend to make the levels and circulating ways larger, to create forwarding facilities for the miner, to admit larger volumes of air to the underground openings, to lessen the severity of the miner's toil, and increase the rate of wages, as well as to multiply the chances of successful results for the capitalists.—J. D.

ROCK AND RIG. A South Staffordshire term, given to a white sandstone full of little patches and shreds of coal; the coal frequently entangled in the sandstone and the two mixed up together in a very singular way.—JUKES.

ROCK CRYSTAL. The use of rock crystal in the manufacture of optical instruments has led to the development of the curious and interesting profession of crystal finding. It is not new in the Swiss Alps, where the knowledge of the crystal finder, and his nerve and endurance, are often put to a severe test. The rock crystal or crystallised quartz is found in pieces of different size, colour, and fineness, sometimes separately, sometimes in groups. The *strahler*—as the crystal finder is called—is equipped with a bar of iron 4 ft. long, bent up at one end, a shovel, a hammer, a back, a strong cord, and a leather sack, and starts for his work early in the morning. He is nearly always alone. He crawls along the flanks of the hills hours together, looking out for any indication of a vein. This may be a long way above him, and he tries to reach it as best he can, being not unfrequently compelled to cut his steps in the rock. His first act, on reaching his find, is to strike it with his hammer, his ear telling him whether the crystals are attached to the walls, separate, or mixed with sand. The most celebrated discovery of large crystals is a recent one made at St. Gothard. A hundred feet above the snow limit, an apothecary, a resident of Berne, saw one evening a vein of quartz 60 ft. long and 4 to 12 ft. thick. A guide was with him, and the two resolved to ascend for an investigation. This, however, had to be deferred till the morning. The would-be finders passed the night in a hut, and rose early to make the ascent. Unfortunately, the morning was misty, and threatened to cut off their retreat. They descended in haste, and were unable to renew their attempt until the following year, when the spring had melted the winter snows. The day at length arrived when they were able to begin work, and by mining the vein they pierced into its inner chambers, and collected 300 cwt. of crystals, the largest of which were bought up by scientific institutions, and the fragments by opticians and instrument makers.

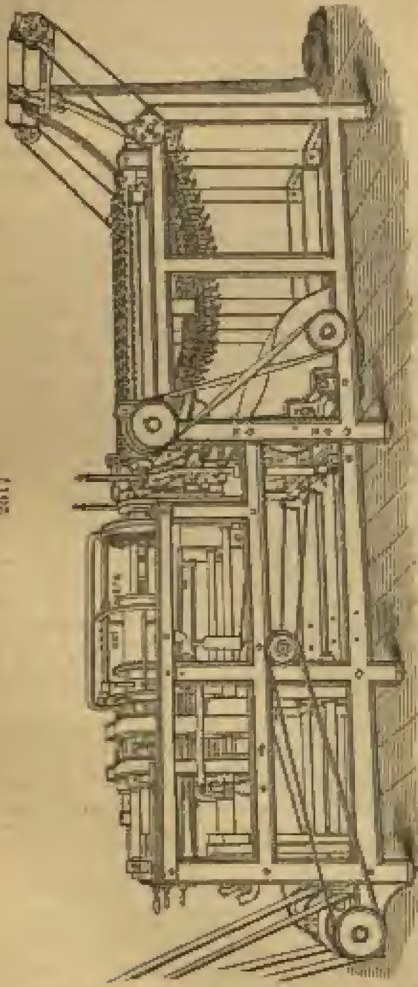
ROPE-YARN SPINNER. (ROPE MAKING, vol. iii. p. 713.) Notwithstanding the increasing use of iron and steel wire ropes, hemp and other fibres are still used with advantage in both steam and sailing vessels. In the article referred to, a full description is given of the machinery employed by the best rope-makers. It is only necessary in this place to notice one machine, which possesses many points of excellence. The annexed woodcut (*fig.* 2517) clearly shows the construction of a very beautiful automatic spinning machine, which has been introduced by Messrs. Lawson and Son, of the Hope Foundry, Leeds.

It is generally admitted that machine spun yarns are not of a quality equal to those spun by hand, mainly by reason of their being deficient in gloss of skin; but the automatic spinner, by means of its simple and admirable mechanical appliances, turns out a yarn which is even more level than, and superior in appearance to, hand-made yarns; and, moreover, by the peculiar nip, the yarn can be made of any degree of softness, to suit the kind of rope which is desired to be made.

The feed is self-adjusting, by means of a lever and gut-band actuating three differently-speeded pulleys, whereby every excess or deficiency of material in the sliver causes a corresponding increase or decrease in the velocity of the feed; and thus no ordinary irregularity of sliver can either cause rupture of the yarn or an entire stoppage of the machine; and the apparatus may therefore run continuously for weeks with no other interruption or cessation than that requisite for the removal of the full bobbins and their replacement by empty ones.

The bobbins are placed horizontally, and have a traversing motion imparted to them to and from the feed, while by a simple auxiliary appliance a perfectly uniform tension of any desired degree of force is maintained on the yarn throughout the entire process of spinning and winding on the bobbins. By the special twisting action perfect uniformity of twist is attained, so that none of the fibres override any of the others, while the appearance termed 'coggled' yarn, which is peculiar to ordinary machine-spun yarns, is completely obviated. In consequence of this perfect parallelism of the fibres the yarn spun by this machine is the best possible, of surpassing

strength, and is considered by experts to be superior to that manufactured either by hand or by any other mechanical process.



2917

These machines are used by many of the leading makers, in conjunction with Good's Patent Spreader, by means whereof the hemp is taken from the bale, heckled, spread and delivered in a sliver at one operation. Good's machines are so powerful and well adapted to their work that from 4 to 6 tons of material per day can be passed over, treated and delivered by them. Thus fed, Messrs. Lawson's Automatic Spinner will produce daily from 140 to 220 lb. per spindle, according to the nature of the work.

ROSANILINE BLUE (*triphenylated.*) See Aniline, Electrolysis of.

ROSCOELITE. See Vanadium.

RUBY. (Vol. iii. p. 724.) Mr. Greville Williams stated in a paper, *Researches on Emeralds and Beryls*, that artificial rubies made by Gaudin's process had a lower specific gravity than the true natural ruby. Mr. G. Williams remarks on this :—

'I there assumed the density of the ruby to be 3·53, on the authority of Brisson (Gmelin's *Chemistry*, Cavendish Society's translation, vol. iii. p. 305), and that of the sapphire as 3·56, according to Muschenbroek (*loc. cit.*). Having occasion, in extending my experiments on the subject, to take the specific gravity of several rubies and sapphires, I found their density to be very much higher than the number given in Gmelin's *Chemistry*. On referring to other works ("Brooke and Miller," Watts's *Dictionary of Chemistry*, "Rammelsberg," &c.), I found the numbers given in them to be generally between 3·9 and 4·0; Professor Church also found a blue sapphire to have a density of 3·979, and a yellow one, 4·30. My own determinations, made upon very fine stones, gave me for rubies 3·95, and for sapphires 3·98. Assuming 3·95 as the average specific gravity of the ruby, it will be seen that Gaudin's rubies as first made by me were 0·5 lower in density than the native ruby, instead of 0·3 as given in my former communication. I have, however, recently succeeded in preparing some fresh specimens of artificial rubies by the same process, but with a higher density, namely 3·7; this number is only 0·25 lower than the native ruby, and I think it probable that the true density of the ruby might be obtained if the frothing, which takes place to a greater or less degree under the intense heat of the oxyhydrogen blow-pipe, could be completely avoided.'

The Ruby or Red Sapphire in Australia.—This is much more rare than the blue gem. The late Mr. Stutchbury reports its occurrence with sapphire, chrysolite, hyacinth, amethyst, and other gems in the Cudgegong between Eambi and Bimbijong, and in Mullen's and Lawson's Creeks, which fall into the Cudgegong. And the Rev. W. B. Clarke found it at Tumberumba with similar gems. It is found too at Mudgee, but is not common, and usually of small size.

Ruby, Spinel, in Australia.—Cubical system. Small well-formed octahedra are by no means rare; the colour varies from pale brown, red, deep crimson, green, to black.

It is found in most river deposits containing gold, as in the sands of the Severn and its tributaries, at Uralla, Ringera, Two-mile Flat, Bathurst, Macquarie, and Cudgegong Rivers. For manufactured rubies, see SAPPHIRES.

RUSINA. The name of an agent used in tanning, for removing the hair from the skins. It consists mainly of sulphide of lime, with some mineral poison, probably arsenic, in one of its combinations. See TANNING.

RUST, THE PREVENTION OF. Dr. W. H. STERLING some years since introduced a method of forcing unoxidisable bodies into the pores of metals. Paraffin especially was recommended by him. Vaseline, a residuary product in the distillation of paraffin, is now much used for protecting bright steel goods from rust, with the best possible result.

Professor BARFF has patented a process for producing on the surface of metals an artificial coating of an oxide which will not undergo further oxidation, and which is said fully to protect the metal beneath it.

A well-known experiment led Professor BARFF to try whether it was possible to produce upon iron and steel surfaces a coherent and adherent coat of the black oxide, and after many experiments he succeeded in utilising superheated steam for the purpose. The method, briefly described, consists in raising the articles to be made non-oxidisable to a temperature of, say, 500° Fahr. in a suitable chamber, and then subjecting them to the action of superheated steam for periods of five, six, or seven hours. Differences of temperature and variations in the time of exposure are employed for different articles; but so far as experiments have yet been made, a temperature of 500° Fahr. has been found sufficient for most articles. Thus, for surfaces of polished iron and steel, it is advisable to keep the temperature down to 500° Fahr., and to allow the articles to remain until the operation is completed. It has been found that articles so treated will resist any degree or amount of moisture with which it is probable they can be brought into contact, in a house or other similar building; but will not resist the action of long-continued rain when exposed to its influences, because the black oxide exists only as a very thin, and probably imperfect, film. A temperature of 1,200° Fahr. and an exposure to superheated steam for six or seven hours suffice, however, to so change the surface of iron articles that it is unaffected by the action of water, even if the latter is impregnated with the acid fumes of a laboratory. So far as it has been possible to test the point, the film of magnetic oxide will protect the metal for an indefinite time. It is beyond our present purpose to enumerate even a few of the many uses to which iron prepared by this process can be put; but it will be obvious that non-rusting bolts, ties, and fastenings are of very considerable importance indeed, sufficient to stamp the process as a valuable discovery.

Professor BARFF himself points out that it would be an advantage, from a sanitary point of view, in connection with water-pipes, as protected iron pipes could be used instead of lead inside the house, while the mains and service-pipes might by its means be entirely protected from rust. The surface of black oxide is difficult to remove by means of emery or a file, and is not liable to chip or scale off by the action of ordinary variations of temperature; but if any portion of a protected article is deprived of its protecting coat, the metal, of course, becomes oxidised, but the rust does not spread. In the case of painted iron, if a portion of the paint flakes off the rust proceeds along the surface under the coat of paint, which is forced off in large flakes; and in galvanised iron, if the zinc coating is worn off or removed from a portion, the destruction sometimes goes on even more rapidly than is the case with ordinary unprotected iron. Similarly, the production of a coat of magnetic oxide on saucepans and other cooking utensils will be an improvement on the tinning and enamelling processes; for in the one case the saucepan will be uninjured if allowed to get red hot, in the other all danger of lead and arsenic in the enamel is avoided. There is some doubt whether it will be possible to apply the process in the manufacture of steam-boilers, and in this connection it is curious to note that the reason why the tubes of Mr. PERKINS's boilers, which were subjected to pressures of 450 lb. and upwards, were unaffected with rust, was because of the production of this magnetic oxide, the protecting influence of which was, however, quite unsuspected. Should it be found possible to coat steam-boilers and iron ships with the magnetic oxide in such a way as to protect them from the effects of corrosive action, the discovery will rank as one of the most important of the century.

Dr. PERCY, in a communication read before the Iron and Steel Institute, contests the originality of Professor BARFF's patent; he expresses some doubts as to its value and the practicability of applying the process generally.

RUTHENIUM. See PLATINUM.

S

SAFETY APPARATUS FOR MINES. The following plan, invented by a German engineer, is on a different principle from all those in use up to the present time, inasmuch as it arrests the free-falling cage without any shock, and therefore assures, in a far greater degree, safety and reliability. As soon as the rope which bears the cage is broken, a spring (which up to this time is held up by the winding rope) comes into action, and looses two claws, which grip a rope that is hanging still in the shaft for the whole length. The claws are so arranged that by the individual weight of the cage they clip faster and faster; the arrest does not depend altogether on the action of the spring, which only gives the force to bring the claws into play, and the cage must directly come to rest. Instead of causing a shock, the rope follows first of all quite freely the movement of the cage, retards its descent by degrees, and brings it at last quite to a stand. The safety rope is made fast at its lower end at the bottom of the shaft, whereas at the mouth of the shaft it passes over a sheave having the end free. At its upper end it is bound with small ropes, to which a series of weights are attached, which in the aggregate are many times heavier than the weight of the loaded cage. Under normal circumstances these weights cause no tension of the safety rope whilst they lie still on the ground; the gripping of the rope by the falling cage brings them into action—not all at once, but successively—from the lightest to the heaviest weight. This ingenious arrangement appears to give elasticity to the safety rope, and by experiment on a small scale has been proved to be completely safe.

SAFETY LAMPS, Bainbridge's. Whilst assisting at experiments for testing various safety lamps for coal mines, conducted by the Safety Lamp Committee, Mr. Emerson Bainbridge observed that ordinary safety lamps having a vertical gauze surrounding the light were rendered unsafe in a current of explosive mixture moving at the rate of 12 ft. per second, the velocity with which the explosive current impinged on the gauze causing it to become hot more quickly than it could radiate heat, the gas on the outside of the lamp thus becoming ignited. Whilst the gauze of the Stephenson lamp has only an inch or two exposed above the inside glass, the Clanny lamp has several inches above the glass, and the Davy lamp is surrounded by gauze from top to bottom. They all are equally unsafe in a current travelling at the above rate, such current causing an explosion in less than 50 seconds. Observing these facts, Mr. Bainbridge constructed a lamp with no vertical gauze, and with inlet and outlet of the air so delicately balanced as to cause the quantity of air entering the lamp to be just sufficient for complete combustion. The lamp consists of a tapered glass cylinder surrounding the wick, and surmounted by a short brass cylinder of smaller diameter, at the top of which is a circular gauze which is screwed up from the inside. The plate at the top for sheltering the gauze is attached to the body of the lamp by small bars, in order to allow the heat from the lamp to be easily carried away. At the top and bottom of the glass rings of a non-conducting material are used for the purpose of keeping the glass cool. The ring for screwing up the glass passes into a thread of a smaller diameter than that of the screw of the bottom of the lamp, this arrangement saving considerable time in screwing up the glass. The air enters the lamp through a number of small round holes, which are drilled through the brass hoop which forms the bottom of the frame for the glass.

The following tables show the result of experiments with the various lamps:—

Table No. 1.

Name of Lamp or Inventor	Velocity at which the Explosive Mixture of Fire-damp and Air passed through the Lamp to the Outer Air	Length of Time the Lamp was exposed to the Current before an Explosion took place
	Feet per Second	Seconds
Davy	8	15
Clanny . . .	9	45
Stephenson . .	11·2	28

TABLE No. 2.

Description of Lamp	Velocity of Explosive Mixture	Duration of Experiments	Result of Experiments	Remarks on Appearance of Gas inside Lamps
	Feet	Seconds		
New Lamp . .	4	5	Out	—
DAVY . . .	11·8	1	Exploded	—
HANN . . .	11·8	10	Not out	Long yellow flame
New Lamp . .	11·8	16	"	Low blue flame
" . .	21	16	"	" "
HANN . . .	21	12	"	Long white flame
New Lamp . .	26	21	"	Low blue flame
" . .	33	41	Out	" "
" . .	54	22	"	" "
HANN . . .	64	23	Exploded	

TABLE No. 3.

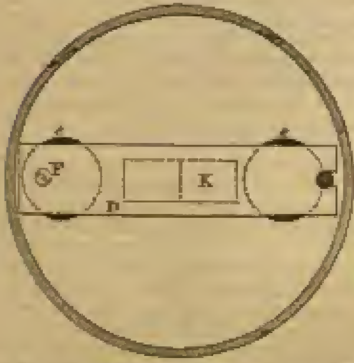
Experiments to test illuminating power and economy of burning.

Description of Lamp	Illuminating Power; being Number of Lamps equal to one Sperm Candle, as tested by Photometer at the Sheffield Gas Works	Number of Hours taken to burn 2 oz. of Oil, the Light being as nearly as possible the same as when the Experiments given in Column 2 were made
New Lamp . .	2·20	15
CLANNY Lamp .	2·08	16½
DAVY Lamp . .	4·63	16

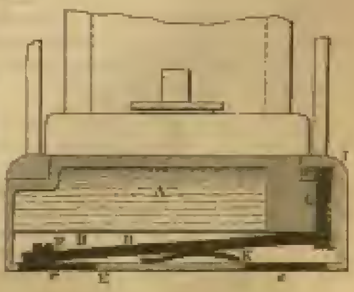
It will be seen from Table No. 2 that at a low velocity of the explosive mixture the lamp tried by the author was extinguished, and that from a velocity of 11·8 ft. per second to the extremely high velocity of 54 ft. per second, no explosion in any instance ensued, but in every case the gas on entering the lamp burnt with a low, blue flame at the bottom of the lamp round about the air-holes, this flame only being about ⅛th of an inch high. Thus a comparatively low temperature inside the lamp was maintained in each experiment.

An objection to this design of lamp consists in the flame being protected by *glass without gauze*. On this point the inventor states that an explosion through the use of a glass lamp in place of a lamp surrounded by gauze, or an accident by explosion caused by the breakage of a glass lamp is an extremely rare occurrence, and that there are few such cases on record. As the lamp goes out in a *slow* current of explosive mixture, and burns with such a low blue flame in a *rapid* current, he thinks that the glass would be less likely to become heated and crack than in the case of other safety lamps where glass is employed.

2518



2519



CRAIG *and* BIDDER'S *Safety Lamp*.—This is really an arrangement which may be fitted to any safety lamp, for the purpose of securing it from the attempts made by

the miners to open it in the colliery. The principle is that a magnetic bar secures the gauze frame of the lamp to the lower part; this is entirely enclosed, and can only be moved by bringing into use a powerful magnet, which, acting through the case which protects the bar, moves the bar and thus unlocks the lamp.

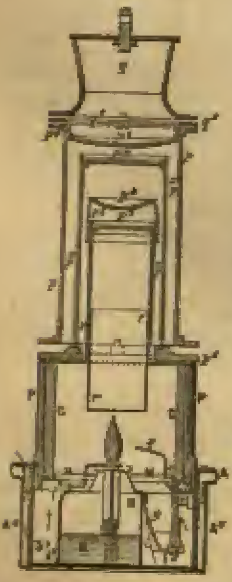
Figs. 2518 and 2519 show one arrangement of the lamp. The gauze frame is screwed on to the oil-receiver A, by the ring I, in the usual way. This ring has a hole H, to receive a pin G, attached to a piece of soft iron D, and pressed upwards by the spring K. The joint is so made that the gauze can be screwed on to the last turn, when the pin being forced into the hole H, it will be prevented from being unscrewed. *e e* are two circular pieces of iron let into the brass bottom of the cistern A, and correspond to the two poles of a magnet, which is to be used for unlocking. When it is desired to unfasten the lamp these circular pieces are placed on the top of the poles of a powerful horse-shoe magnet, which, by attracting the bar D, overcomes the resistance of the spring K, draws the pins G from the hole H, and unfastens the lamp.

LANDAU'S *Safety Lamp.*—This lamp is extinguished when the gas present in the air of the mine is sufficient to impede respiration, and it cannot be opened without extinguishing the light.

The way in which atmospheric air is supplied to the flame in this form of lamp is as follows: At the base there is an annular chamber, the upper edge of which forms a horizontal periphery, in which are perforations protected either by wire gauze or perforated metal-plate. Through these orifices the air enters, passing into and circulating in the chamber. Beneath a portion of the perforated periphery there are holes in the vertical side of the chamber beneath, giving passage to the flame of the air necessary to maintain combustion. Thus explosive gas will not burn inside this lamp, because it cannot enter it unless there be a strong down draught, and when that takes place it extinguishes the flame. The reduction, gradual or otherwise, of the flame is a useful warning of danger. When the gas is in excess the lamp goes out. The mechanism for extinguishing the lamp is very ingenious and effective, as are also the arrangements with regard to burners, wick-holders, and other details.

The peculiar features of the lamp are two, and in both there is an improvement upon the lamps in ordinary use:—First, the contrivance for extinguishing the flame as soon as any attempt is made to open it; secondly, the careful regulation for the admission of air and the exit of products of combustion. All air entering the lamp passes through two thicknesses of wire gauze, and enters quietly without draught. We have immersed the burning lamp in a mixture of marsh-gas and air, as well as directed a jet of coal-gas upon it—in both cases with the same result, namely, immediate extinction. The light given by this lamp is, of course, much superior to that of the DAVY.

2520

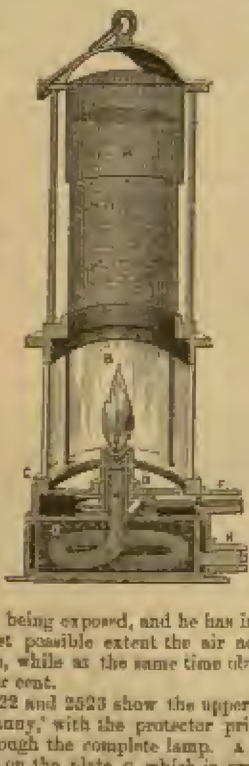


The following description of the diagram will more clearly elucidate the construction of this ingenious lamp. A is an annular air-chamber, formed in the lower portion and having three series, each consisting of five holes, *a*, disposed uniformly round the circumference, thus leaving between them three portions blank, or unprovided with holes. These perforations are protected by wire gauze, and through them the atmospheric air passes, in order to circulate within the annular chamber. The casing, A^x, forms the outer wall of the annular chamber, and in the inner wall are three circular holes, a^2, protected by wire gauze, but arranged so as to be between the three series of smaller holes above mentioned. The air for keeping up the combustion of the lamp enters through the perforations, *a*, *a*, circulates through a portion of the air-chamber, A, and passes through the holes, a^2 a^2, to reach the burner, *b*. B is the oil-holder, resting on the bottom of the annular chamber, and fitted in a socket, b^4, in such a manner that it can be turned partially round. A recess, as shown, is formed in the oil-holder to receive the lever hinge or actuating contrivance, *e*, of an extinguishing plate, *f*; and the oil-holder is united to the socket, b^4, in the bottom plate of the annular chamber by a bayonet joint; that is to say, a stud or pin on the oil-holder engages in a right-angled slot in the socket, holding back the extinguishing plate, as shown in the figure. A spring, *g*, is attached to the oil-holder, and, when released, permits the extinguishing plate to fall

upon, and therefore extinguish, the lighted wick; but when the oil-holder is so turned in its socket that the back end of the lever, e, engages with the hook, i, on the inner wall of the annular chamber, the plate, f, is held in a nearly vertical position free from the wick, and therefore allows it to remain ignited. F is the upper portion of the lamp; H is a collar or ring screwed into the under side of the upper portion of the lamp, and carrying a hook which, when the two parts of the lamp are fitted together by their conical joint, comes in contact with the lever, e, and when the said upper part is turned—say about one-eighth of a revolution—thus moving the oil-holder with it, the plate, f, though it be moved away from the hook, i, will still be kept raised by the hook just mentioned, and which is not shown in the engraving. If, however, the miner should endeavour surreptitiously to open his lamp by detaching the upper from the lower part, the hook above mentioned will no longer retain the plate, f, in its upright position, and, therefore, the light will be immediately extinguished. In the upper portion of the lamp, as shown, there are three concentric chimneys, p, p^x, and p^2, but the outer one may be dispensed with. The innermost chimney has a wire-gauze diaphragm, p^3, near the top, and also a solid capped top, p^4. There are lateral openings, p^5, in this chimney near the upper part, and a reflector, p^6, is attached to its lower end. To the top of the intermediate chimney, p^x, is fitted a wire-gauze disc, p^7, space being left between the outer periphery of the disc and the inner periphery of the chimney. On the top of the outer chimney, p, is hinged a flanged hollow cap, q, to which is attached the suspending ring by which the lamp is carried.

The 'Protector' Miners' Lamp.—The inventor of the Protector lamp, Mr. W. T. Teale, of Worsley, near Manchester, has contrived a lock that will prevent a naked

2521



2522

flame from being exposed, and he has introduced the use of an oil that utilises to the greatest possible extent the air admitted into the lamp, thus ensuring perfect combustion, while at the same time obtaining an increased illuminating power of at least 25 per cent.

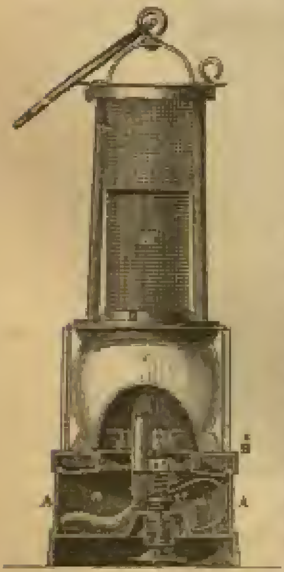
Figs. 2522 and 2523 show the upper and lower portions of the type of lamp known as the 'Clanny,' with the protector principle added; and *fig.* 2521 shows a vertical section through the complete lamp. A is the wire gauze; B, the glass cylinder below it, bedding on the plate, C, which is provided with an aperture, D, screwed to receive the extinguisher-tube. This tube is, in turn, provided with a coarse thread to receive the burner, E, shown in *fig.* 2523, in which same figure also appears the

sliding-cover, L, for closing the oil-reservoir. The reservoir is filled with a sponge, O, in connection with a permanent wick, N, reaching to within a short distance of the top of the burner, the remaining space being occupied by a short asbestos wick, M, which, though unconsumable, may be renewed should occasion require. The 'Protector' principle consists in its being impossible to remove the lower or reservoir portion of the lamp from the upper, without at the same time extinguishing the flame; and this is accomplished in the following manner:—When the lamp is trimmed and lighted, with the extinguisher-tube screwed in its place over the burner, all these parts together are screwed into the plate, C, of the upper portion, from which they may be again withdrawn as long as the bolt, O, sliding in the projection, P, is kept clear of the extinguisher-tube. Directly, however, this is shot home, its hollow, curved end occupies the space between the flanges of the extinguisher-tube, and prevents the latter from following the burner on the latter being unscrewed. The consequence is, that, on the burner being drawn below the tube, even to the extent of one-third of an inch, the flame becomes extinguished, owing to its being deprived of the oxygen necessary to support combustion. The bolt is retained in its place, after being shot, by the small spring, shown in the separate view of the bolt, flying out and butting against the portion marked B of the casing. In the projection, R, works the old screw-lock, turned by a 'key,' it is true, but to imitate which very little mechanical ability is required. This excrescence does not hinder the reservoir portion from being turned round so as to reduce the light, if desired; but it prevents the two parts from being entirely separated, owing to the upper flange of the reservoir coming in contact with the end of the screw.

2523

YATES'S *Safety Lamp*.—Mr. WILLIAM YATES, of 24 Duke Street, Westminster, has been endeavouring to construct a miner's lamp which shall possess all the advantages of the 'DAVY' with none of its defects. To this end he has removed the wire gauze from that part of it which surrounded the flame, and replaced it by a strong lens or bull's-eye glass on one side, and a silver reflector on the other. The result of this arrangement is that his lamp gives a light estimated at twenty times that of the DAVY, and sufficient for all necessary purposes. By this means the temptation to expose the flame to obtain more light is removed. He further provides a complete check against the practice of heating the lamp by means of the flame, for it is placed so low that it cannot be made to approach the gauze either by the breath or by tilting the apparatus. He has remedied a third defect. The lower portion of the apparatus containing the oil-reservoir and the wick, which is screwed to the part which consists of the gauze funnel, the bull's-eye, and the reflector, has a spring bolt attached to it, which catches each time the screw is turned, and finally locks together the two parts of the lamp. The bolt is easily removed by another screw, but this cannot be done without at the same time withdrawing the wick and extinguishing the flame, and it thus becomes impossible to obtain a light by opening the lamp. The new invention thus remedies the chief defects of the old lamp, and those to which the accidents still occurring in mines are chiefly attributed. It is much more expensive than the forms of the lamp now in general use, but Mr. YATES states that the saving of oil effected by its use will in one year pay the additional cost, although this economy in use is only a subordinate consideration—though not on that account the less substantial.

2524



The accompanying engravings will show the construction, *fig.* 2524 being a sectional elevation.

A, A, is the body of the lamp, comprising the oil-reservoir, *a*, *a*, the fixed wick-tube, *b*[1], the movable wick-holder, *b*, and the parts connected therewith; and at *c*, *c*, screwed into the upper part, B, which comprises the gauze chimney, *d*, the lens, *e* (C), and metal reflector, *f* (D). The lower end, B*, of the part, B, is made with a flange and recessed under part, in which there are a number of ratchet teeth, as shown at *g*, *g* (*fig.* 2525), which is a view of the under side of the part B*. The wick-holder or

carrier, b, is capable of being moved up and down in the fixed tube, b^1, by means of a screwed pin, h, passing through a nut made in an arm, b^2, attached to b, and of which the lower end passes through a stuffing-box, i, in the bottom of the oil-reservoir, and is provided externally with a milled head, h^* (x in the general view), whereby it may be turned from the outside when it is required to lower the wick. The screwed pin, h, passes freely through a hole in a cranked arm, which carries at its opposite end a vertical pin, the upper end of which, projecting up into the recessed part, a^*, of the upper half of the lamp, works in guides or sockets, as shown at *fig.* 2526, and is pressed upwards by means of the spring, k, which bears against the cranked arm, i^*, and keeps the upper end of the pin against the ratchet teeth, $g\ g$.

2525

The operation of the various parts of the lamp is as follows:—If it be desired to detach the lower or burner part of the lamp from the upper part, the locking-pin must be drawn down before the lower part of the lamp can be unscrewed. The withdrawal of the pin from the ratchet teeth is effected by turning round the milled head of the screwed pin, which passes through the nut made in the arm attached to the wick-carrier. By so doing the wick-carrier or holder will be drawn down and the light extinguished; the nut will then be brought down on to the end of the cranked arm, which, when forced back, will at the same time draw down the locking-pin out of contact with the ratchet teeth, and allow the lower part of the lamp to be unscrewed; but the light will have been extinguished before the lamp can be thus taken apart. When the lamp has been trimmed and lighted it may be screwed into its place in the upper half; the pin will then bear against the ratchet teeth, being pressed upwards by the spring; the upper end of the pin will rub over the teeth as the lamp is screwed in; but it will effectually prevent the lamp from being unscrewed until the pin has been drawn down in the manner described.

It is by means of the safety lamp that the presence of fire-damp in mines has hitherto been recognised, but its indications are not very exact. Thus, according to Mallard, it is only when the proportion has reached 6·7 per cent. that the Mueseler lamp shows the presence of the gas by a blue aureola round the flame; others say 8 per cent., and then there is danger of explosion. M. Coquillion has just described (1877) to the French Academy two pieces of apparatus, which he calls *grisoumètres*, or fire-damp measurers. One is for determining the quantity of proto-carburetted hydrogen in the mine itself; the other, brought into the engineer's room, serves to control the first by analysis of gas collected at different points of the mine, where the first observations have been made. The principle of both these arrangements is, that hydrogen or any of its carburetted compounds in the state of gas is completely burnt in presence of oxygen, and a palladium wire raised to a white heat. Water and carbonic acid are formed, and a suitable graduation of the apparatus will give the proportion of carbon. The palladium wire may be used not only for carburets but for other gases, so that it may with advantage replace the electric spark in eudiometers. It gives detonation only in the case of a detonating mixture of oxygen and hydrogen, and this detonation is always very weak. M. Coquillion's apparatus may be expected to prove very useful in the study of the questions relating to fire-damp in mines.

SAFFLOWER. (Vol. iii. p. 737.) Carthamus (vol. i. p. 786.) The importation of this dye drug in 1875 and 1876 was as follows:—

	1875		1876	
	Cwt.	Value	Cwt.	Value
From British India:		£		£
„ Bengal	3,029	12,755	3,526	13,700
„ other Countries . .	2	7	225	500
Total	3,031	12,762	3,751	14,200

SAFFRANIN. See vol. iii. p. 737, for a description of the ordinary manufacture of this dye. A. Ott recommends as the best method to treat with syrupy arsenic acid the azotised compounds obtained by acting with nitrous acid upon heavy

aniline oils, containing toluidine and boiling at 198° to 200° C. For the preparation of the nitrous acid M. Orr takes 1 part of starch and 8 parts of nitric acid, which he heats in a water bath. The gas generated is passed through sulphuric acid before being conducted into the aniline oil. When the aniline has become a maroon brown, and crystallises on a watch glass, 100 parts are mixed with 90 parts of arsenic acid at 72 per cent. The arsenic must be added very slowly to prevent too rapid a rise of temperature. It is then heated on a sand bath until a violet coloration appears. M. Orr says that it is necessary to heat 50 grams for at least two hours. The whole is then boiled with water containing lime, in which the violet colouring matter is insoluble. To remove the deposit formed, the whole is poured upon woollen filters, beneath which is a layer of sand. The filtrate is saturated with hydrochloric acid, and an excess of chloride of sodium is added. The precipitated saffranin is purified by solution in acidulated water and re-precipitation with salt.—*Moniteur Scientifique*, 1874.

SAGO. (Vol. iii. p. 738.) Our imports of sago in 1875 and 1876 were as follows:—

	1875		1876	
	Cwt.	Value	Cwt.	Value
		£		£
From Borneo	6,500	4,800	5,735	3,993
„ Straits Settlements . .	350,064	264,371	331,658	233,286
„ other Countries . .	3,793	3,022	827	623
Total . . .	360,357	272,193	338,220	237,902

SALANGAN SWALLOW. The bird which produces the edible bird's nest of the Chinese. The following interesting account of this bird and its works is from *Chambers's Journal*:—

'What sort of thing is the edible bird's nest that ministers to the taste of the luxurious Chinese? It is that portion of the fabric which serves as a sort of bracket on which the nest itself (made of grass, sea-weed, fibres, small leaves, &c.) is built. There are two forms of this support, one flat like an oyster-shell, the other deep and spoon-shaped. It is a transparent mass, somewhat like isinglass, mother-of-pearl, or white horn, and is of animal origin. It was formerly supposed that this gelatine-like mass might be prepared in the bird's crop, from sea-weed and other marine plants. This, however, is a mistake. If one opens the animal's stomach about the time of building, it is found to contain insects, but no vegetable matter: moreover, in all species of the family of swifts, the crop is wanting. Dr. Bernstein has found that at that season the salivary glands under the tongue are enormously developed. On opening the bill they are seen as two large swellings, one on either side, and these chiefly supply the material in question. They secrete a viscid mucous substance like a concentrated solution of gum-arabic, which can be drawn out of the mouth in long threads; and in the air it soon dries, and is found to be the same (even microscopically) as the bracket material. Blades of grass and similar objects can be stuck together with this saliva; and there is a species of salangan (supposed, but erroneously, to feed on sea-weed) which does not make a pellicle or bracket on which to build its nest, but merely sticks together, by means of its saliva, some grass, dry leaves, and sea-weed, and fixes them directly to the rock. The nests of this species, however, are not of great commercial importance.

'When one of the little birds wishes to begin building it flies repeatedly against the selected spot, pressing each time a little saliva against the rock with the tip of its tongue. This it will do from ten to twenty times, moving away not more than a few yards in the intervals. It then alights, and arranges the material in semicircular or horse-shoe form on the rock, continuing to add saliva; and by the motions of its body from side to side the yet soft saliva is forced out over the harder parts, producing those peculiar undulatory bands which give the nest a stratified appearance. It is thought not unlikely that part of the secretion used by the bird comes from the largely developed glands in its stomach; also, that gelatinous matters picked up in the surge are employed in the construction of its nest. The salangan never uses the same nest more than once, and that for only a month, and after the young brood is flown, the nest soon decays and falls to pieces. The salangans are generally found to build their nests in the rocks of the coast, but not always. Thus, multitudes of them are met within the limestone caverns of the district Bandong, which is nearly in

the middle of Java, and ten miles from either the north or the south coast. It is ascertained, too, that these birds leave their nests every morning to seek their food along the coast, so that they must travel at least a score of miles daily; in fact, these busy creatures, like the swifts of our summer, appear to be on the wing the whole of the day long.

'The greatest trade in birds' nests is done with Canton, the entire import there being reckoned at 1,200 piculs or 168,000 lb. We may reckon on fifty nests to the pound, so that altogether 8,400,000 nests, or, from three pluckings, the products of 2,800,000 pair of birds, are annually introduced into China. There are, principally, two kinds of nests distinguished in Canton—the mandarin nests, and the ordinary; the former, or perfectly white kind, are sold at three to four thousand dollars per picul, which is double their weight in silver. Each pound thus costs in China twenty to thirty dollars—a quite exorbitant price, compared with that which the salangan pluckers themselves receive for their dangerous work, and which is, at the most, only ten to twelve per cent. of the market value. The second quality of nests are sold at sixteen hundred to twenty-eight hundred dollars. There is a small trade done in the kind of nest built by the so-called seaweed-eating salangan, referred to above; these are sold at two hundred dollars the picul. The nests are dissolved in water or broth, and so taken as soup. It is highly spiced with minor substances. This forms an *entrée* which is rarely wanting on the tables of the wealthy Chinese, and never from that of the Imperial Court at Pekin. The Chinese set a high value upon it, considering it one of the best stimulants; but for this opinion there seems to be little or no ground. The most recent analysis of the nests we owe to Professor TROSCHEL, of Bonn. He finds that the material does not consist of specially nourishing or stimulating substances, but is quite similar in constitution to any animal saliva.'

SALICYLIC ACID. See SALICIN, vol. iii. p. 739, and WATTS's *Dictionary of Chemistry*. KOLBE and LAUTEMANN (*Ann. Ch. Pharm.* cxv. p. 177) published in 1860 their method of obtaining this acid from carbolic acid. It had been obtained in 1844 by CAHOURS from the oil of winter-green. It exists also in the flowers of *Spiræa Ulmaria* (*Gaultheria procumbens*), but KOLBE's method possesses many advantages. WATTS gives this acid the formula $C^7H^6O^3 = \left.\begin{matrix}(C^7H^4O)'' \\ H\end{matrix}\right\}O$.

Within the year 1875 KOLBE has discovered and drawn attention to the peculiar preserving and disinfecting properties of salicylic acid. This has been most fully confirmed, and hence it becomes essential that this chemical body should find a place in this dictionary.

Salicylic acid is obtained from carbolic acid by the following process:—The saturating capacity of carbolic acid and also that of a soda lye is determined, and both are then mixed according to equivalents, so as to form carbolate of soda. The solution thus obtained is carefully evaporated to dryness, taking care that the dry mass sticking to the bottom of the vessel is constantly removed by scrapers, and that the mass itself is also constantly crushed with a pestle or other tool, to facilitate its drying out, until at length the carbolate remains as a perfectly dry powder of a rose-red tint. Excess of carbolic acid gives always an inferior dark-looking residue. The dry carbolate is then either put into the retorts at once, or it may be kept for further treatment by putting it, while hot, into vessels which may be hermetically sealed. The fact that carbolate of soda is very hygroscopic explains the necessity for keeping it from the air. After the carbolate is put into the retorts, they are slowly heated to 212° Fahr., and when this temperature is reached a slow current of perfectly dry carbonic acid gas is allowed to enter the retort. The temperature is then slowly increased to 356° Fahr., and may towards the end of the operation reach to 428° to 482° Fahr. About an hour after the beginning of the operation carbolic acid will begin to distil and the process may be considered finished if, at the latter temperature, no more carbolic acid passes over. It will be found that the distilled carbolic acid amounts to just one-half of the original quantity employed. The residue in the retort is basic *salicylate of soda*, which is dissolved, and which, on acidifying with an acid, yields a brownish coloured crystalline precipitate of salicylic acid. For purifying the crude acid as obtained by this process RAUTERT's method is usually employed. The crude acid is placed in a retort and strongly heated to 338° Fahr., when a current of steam at like temperature is injected into the retort. In the presence of the superheated steam the acids distils at once; and after a short time nothing remains in the retort but a black resinous mass. The apparatus must be arranged with a movable wire passing up the neck of the retort, so that it may be kept free from crystals.

M. R. WAGNER gives a statement of the uses to which this acid can be applied in the arts and manufactures:—

A concentrated solution of salicylic acid applied to fresh meat is said to keep it

in good condition for a long period, if it is placed in well-closed vessels. In the manufacture of sausages and such foods it is found very useful.

Butter containing a little salicylic acid will remain fresh for months even in the hottest weather. It prevents the moulding of preserved fruits, and the formation of mould in vinegar.

Glue is rendered more tenacious by its use, and the decomposition of gut and parchment, or of skins during the process of manufacture, is prevented. Weavers' or booksellers' glue and albumin may be preserved by the use of salicylic acid.—R. WAGNER: DINGL. *Polyt. Jour.* ccxvii.

HERMANN ENDEMANN (*Jour. P. Chem.* xii.) states that 1 part of salicylic acid in 200 parts—especially in acid solutions—prevents the development of bacteria. He also states that phosphates combine with salicylic acid and render it ineffective.

H. KOLBE, in the same journal, describes his experiments with E. VON MEYER:—

Pieces of beef and mutton were thoroughly rubbed over with dry salicylic acid and pressed into glass beakers, covered with parchment paper soaked in a warm solution of salicylic acid. The meat kept for several weeks and then putrefied. Pieces of meat were immersed for some minutes in a hot solution of salicylic acid and then placed in covered jars. They kept good for several weeks in summer, then became putrescent and mouldy. Better results were obtained by immersing the meat in a hot solution of the acid, to which sulphate or chloride of potassium was added. The meat so treated kept good for a long time in glass vessels covered with paper, and after washing with warm water proved tender and good when boiled or roasted.

Bread may be kept fresh and free from mould for six or eight weeks by means of salicylic acid.

Salicylic acid added to new wine entirely prevents after-fermentation. A grain or two of the acid added to a bottle of wine prevents it becoming stale or sour when left open. Beer in like manner keeps well for about four months. The following experiments are given:—

Beer brewed in January 1875.

Salicylic Acid added	Examined in August 1875	Examined in December 1875
Grains		
0	Sour.	Sour.
2·5	Not good tasted.	Sour.
5	Good tasted and in good condition.	Good tasted.
10	Good, sparkling, and clear, of good taste and aroma.	Good in every respect.
20	Good, sparkling, clear, and full-bodied.	Clear; excellent in every respect.
40	Rather too new in taste; very good.	Full-bodied and very sparkling.

SALT. Rock salt is obtained in this country from the New Red marls of Cheshire and Worcestershire, and in Ireland, from near Belfast. Recently deep borings have disclosed the fact that very extensive beds of salt exist beneath the ironstone beds of Cleveland. The white salt is obtained by evaporating the brine pumped from the pits, or by dissolving the rock salt and allowing the solution to crystallise.

Salt, Production of, in the United Kingdom, in 1876:—

	Tons
Rock salt	154,531
White salt	2,118,725
	2,273,256

CHESHIRE.—Northwich, Middlewich, Winsford, &c.:—

	Tons
White salt	1,250,000
Rock salt	150,000
	1,400,000

The quantities of Rock Salt and White Salt sent down the River Weaver in each of the last ten years:—

For the Year ending	Rock Salt	White Salt	Total
	Tons of 20 cwt.	Tons	Tons
March 31, 1868 . .	49,759	868,679	918,438
„ 1869 . .	58,696	901,566	960,262
„ 1870 . .	67,410	901,158	968,568
„ 1871 . .	82,765	930,551	1,013,316
„ 1872 . .	91,084	996,381	1,087,465
„ 1873 . .	95,429½	918,068	1,013,497½
„ 1874 . .	99,814	849,234	949,048
„ 1875 . .	100,562	945,539	1,046,101
„ 1876 . .	109,334	1,009,657	1,118,991

Staffordshire and Worcestershire:—

Shirleywich, &c. . . . . . . }
Droitwich . . . . } 255,000 tons.
Stoke Prior . . . . }

Ireland:—

Rock Salt . . . . 32,310 tons.

Salt exported to Foreign Countries in 1876 as compared with the two previous years:—

Countries to which Exported	Quantities			Value		
	1874	1875	1876	1874	1875	1876
Salt, Rock and White:—	Tons	Tons	Tons	£	£	£
Russia	81,103	61,144	90,663	61,095	42,726	53,082
United States . .	180,281	220,296	218,828	164,144	177,471	165,906
British N. America .	56,429	57,930	61,737	39,067	34,462	27,967
British India . .	275,900	329,141	252,305	220,158	248,546	146,382
Other Countries .	235,396	249,003	231,005	176,729	173,352	146,220
Total . .	828,109	917,514	854,533	662,393	676,556	520,547

It is of some interest to note here the analysis of the brine derived from the salt spring at Walker, from which the first quantities of alkali made in England were produced. The analysis was made by a Mr. G. Woods, and is stated by Mr. R. C. Clapham as follows:—

Contents in 1,000 grains of Brine.

Chloride of sodium . . . . . . 32 grains
Chloride of calcium . . . . . . 10 „
Chloride of magnesium . . . . . }
Carbonate of lime . . . . . } 1 grain
Carbonate of iron . . . . . }
Silica . . . .

43 grains

It was upon this brine that the experiments of Mr. Losh and the Earl of Dundonald were first commenced, and continued until the repeal of the duties on salt.

SALT, ROCK, *in Prussia.* See Prussia, Mineral Production of.

SALT-CUTTING MACHINE. *Experiments with a Rock-salt Cutting Machine at Wieliczka.*—'The working of rock salt by the ordinary method of excava-

ting with a pick and blasting the undercut mass is attended with the disadvantage of making a large amount of small salt, besides giving lumps of irregular form which are inconvenient for carriage. It has therefore been considered desirable to substitute, if possible, the use of cutting machines for hand labour in the Wieliczka mines, and for this purpose experiments have been made with a machine supplied by Stanek and Reska, of Prague. The method of working the salt at present used is to divide it into rectangular blocks by grooves about 25·6 in. deep both at the top and bottom of the bed, and vertical cuts of the same depth from 6 to 10 ft. apart. The blocks so released are brought down by wedging and broken up for sale, into lumps varying from 80 lb. to 88 lb., and in order to satisfy these conditions it was necessary to employ a "Universal" machine, capable of cutting at any angle. The maximum depth of cut required is 30 in., and the vertical distance between the roof and floor of the salt-bed is 4 ft.

'The cutting arrangement is similar to that of Winstanley and Barker's coal-cutting machine, i.e. a large toothed wheel carrying steel cutters on the circumference, mounted at the end of a lever so as to move radially while at the same time it is slowly rotated by a pinion; but, unlike that machine, the construction is, by reason of the various directions in which it is required to work, exceedingly complicated, there being no less than four changes of motion between the driving axle and the cutting wheel; the arrangements being generally similar to those of an engineer's radial drilling machine, with additional movements for varying the plane of the cutting wheel. The machine is self-acting, being moved on a line of railway by a hauling chain passing over a drum under the framing, the ends of which are made fast to fixed traversers at either end of the gallery. The driving engines have cylinders with a stroke of 7·5 and 12 in. Compressed air is used as the motive power. With a pressure of 2·36 atmospheres, the engine makes one hundred to one hundred and twenty revolutions per minute, which is reduced by the various trains of gearing wheels to eight revolutions of the cutting wheel. This has twenty teeth, and seven cutters to every four teeth, so that thirty-five blows are struck in each revolution, or two hundred and eighty per minute, against the surface of the rock. The maximum rate of movement of the machine in undercutting along a face is 4 in. per minute, the corresponding depth of cut being 0·476 in. per revolution.

'The experiments were commenced in July 1876, upon a bed of salt nearly 6·5 ft. thick, but varying irregularly in dip in all directions, upon which a working face of 105 feet had been prepared. The horizontal cuts were put in from 0·4 inch to 1·2 inch above or below the actual floor or roof of the bed, partly to prevent the small salt being mixed with dirt from the rock, and partly to prevent the roof scaling into the workings, which invariably happens when the entire thickness of salt is removed.

'The results of eight months' working show that the machine can cut horizontally 50 sq. ft. per hour. When slitting vertically to a height of 5·9 ft., the reversal of the cutting-frame headstock occupies about three-quarters of an hour, so that the rate of progress is reduced to 30 or 40 sq. ft. per hour.

'The cutting points, made of cast steel, will cut a surface of 452 sq. ft. in clean salt without requiring to be reset, and each set will bear sharpening five or six times before they are worn out, or 2,712 sq. ft. can be cut with one set of points. If, however, bands of anhydrite or sandstone are met with, the points are ground off immediately.

'The average cost of cutting by the machine appears to be about 90 kreuzers (21·6d.) per sq. mètre, as against 1·15 florin (27·6d.) per mètre paid for hand-work. The principal advantage is, however, to be found in the diminished proportion of small salt to lumps, the latter being worth about 7s. per ton more than the former. In the ordinary way, working by hand, the percentages are lumps 75 and smalls 25, while by the machine 83 per cent. of lumps and 17 of smalls are obtained.

'Bessemer steel is employed for all the moving parts of the machine, except the cutting wheel and driving pinion, which are of crucible steel. The cost is about 430*l.*, and that of the air-compressing arrangements, which are designed to drive other machines as well, 900*l.*'—A. Janota, *Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xxv. p. 227. Translated in *Abstract Papers of Foreign Transactions*, by Institute of Civil Engineers.

SALTPETRE. (Nitrate of Potash, Nitre, vol. iii. p. 954.) Potash is now obtained from beetroot. The uncrystallisable sugar of the beet—which is considerable in some varieties of the plant—is converted into alcohol by the ordinary process of vinous fermentation and subsequent distillation; the residuary mass is calcined, and the potashes separated in the ordinary way.

Our importations were as follows in 1875 and 1876:—

	1876		1877	
	Cwt.	Value	Cwt.	Value
		£		£
From Germany	24,994	31,650	14,378	13,975
" Holland	4,837	6,117	3,305	3,450
" British India:				
" Bombay and Scinde .	4,521	3,728	1,702	1,234
" Madras	5,507	4,031	7,208	6,600
" Bengal and Burmah .	267,947	230,906	232,683	211,697
" other Countries . .	4,744	2,948	1,102	1,197
Total . . .	282,550	287,290	260,579	238,053

SAMARSKITE. (COLUMBIUM, vol. i. p. 903.) This mineral is found in the mica mine, called Wiseman, near the river North-Toe, Mitchel county, North Carolina.

Its hardness is 5·5 to 6. It is difficult to establish this exactly, by reason of the extreme fragility of the mineral. Its density is = 5·72. The composition of the mineral has been determined by LAWRENCE SMITH (1); by Miss ELLEN H. SWALLOW (2); and by Professor ALLEN (3):—

	1	2	3
Columbic acid . . .	55·12 }	54·06	{ 37·20
Tantalic acid	— }		{ 18·60
Tungstic and stannic acid .	0·31	0·16	0·08
Yttria	14·49	12·84	14·45
Oxide of cerium . . .	4·24	5·17	4·26
" uranium . . .	10·96	9·91	12·46
" manganese . .	1·53	0·91	0·75
" iron	11·74	14·02	10·90
Magnesia	trace	—	Ca 0·55
Loss of iron	0·72	0·52	1·12
Insoluble residue of oxide of cerium . . .	—	1·25	1·12
	99·12	99·74	100·36

—Mr. J. LAWRENCE SMITH, on *New Colombates: Annales de Chimie et de Physique*, October, 1877: see *Text-book of Mineralogy*, by DANA.

SAMPLING ORES. See ORES, SAMPLING OF.

SAND FOR MOULDING. The best sands for the purposes of the moulder are, generally, the alluvial deposits, found in the beds of rivers or in estuaries. Those that contain the largest amount of pure silica are preferred. Casting sand is a matter of so much importance, that it is brought, at considerable cost, from great distances. The sand deposits at the base of St. Agnes Beacon, Cornwall, are much in request for this purpose, and, being very refractory, they are also much used for lining the copper furnaces. A sand found near the Great Orme's Head is also much sought after. Some of the sands of the coal measures are preferred in many of the iron-producing districts. The great point appears to be to have a due admixture of silica and alumina, and freedom from lime or magnesia. The sand should hold well together without being tenacious. For the chemical constituents of sands, consult the descriptions of the rocks from which they have been derived. Sands are most frequently disintegrated quartz rock, but they are often formed by the wearing down of other rocks, and not unfrequently by the grinding up of shells. There are numerous deposits of sand spread over these islands which appear to belong to the glacial epoch, and some of them to an earlier geological age.

The following analyses of sand are given in PERCY'S *Metallurgy*, vol. i. p. 239. Dr. PERCY quotes from M. KAMPMANN, who has given the analyses of sands employed for moulds in various foundries:—

	1	2	3	4
Silica	92·083	91·907	92·918	90·625
Oxide of iron	2·498	2·177	1·240	2·708
Alumina	5·415	5·683	5·850	6·667
Lime	traces	0·415	traces	traces
	99·996	100·182	100·012	100·000

1. Sand from the foundry of M. Frémont, at Charlottenburg. 2. Sand employed in Paris for bronzes. 3. Sand from Manchester. 4. Sand from the establishment of Sagua, near Stromberg.

According to M. Karmann, a good sand for moulds may be artificially made from the following mixture:—

Fine quartzose sand	93
Red English ochre	2
Aluminous earth the least possible calcareous	5

In the Museum of Practical Geology is a very fine iron casting, which was exhibited at the Paris Exhibition in 1855. It is a circular disc, 40 in. in diameter, and about $\frac{3}{16}$ths of an in. in thickness, presenting a pattern of elegant perforated tracery-work; its surface is remarkably smooth, and the casting is sharp and even: it was produced at the works of Count Stolberg-Wernigerode, at Ilsenburg, in the Hartz Mountains. The sand, which adhered to the surface of the casting as it came from the mould, was purposely left attached, and of this a portion was taken for the analysis, which was made in the laboratory of the museum by Mr. J. Spiller:—

Silica	79·02
Alumina	13·72
Protoxide of iron	2·40
Oxide of copper (CuO)	trace
Magnesia	0·71
Potass	4·58

This sand is stated to consist of three different kinds of material, namely, common argillaceous sand, sand found in diluvial deposits, and sand from solid sandstone. As the first two contain clay, they are carefully heated to dehydrate the clay. The sandstone is pounded under a hammer, and mixed with an equal weight of each of the other two kinds of sand. The mixture is ground by iron balls in a revolving drum, and afterwards passed through a wooden cylinder, which moves up and down. It is thus obtained in the state of the finest flour, which in moulding may be made to receive the most delicate impress. The moulds used in making the so-called 'lace-castings' of cast iron are also prepared with this flour of sand, the patterns being formed of stamped and perforated paper. Dr. Percy says a valuable casting-sand is obtained from the New Red sandstone at Birmingham; there is a quarry of this sand at the Old Cemetery, the value of which one of the directors informed him some years ago was estimated at not less than 20,000*l*.

SANDERS WOOD, RED, or *Saunders*, or *Sandal Wood*. (Vol. iii. p. 751). The red matter of the Red Sanders Wood (the Red Indian dyewood obtained from *Pterocarpus Santalinus*) is always accompanied by a brown colour which interferes with its use for dyeing. A new process for separating this has recently been published.

The principles found in sanders are—(1) a bitter brown extractive matter sparingly soluble in cold water, but readily soluble in hot water; (2) a red matter (*santalin*) insoluble in water, soluble in alcohol and hot alkaline carbonates. This principle undergoes a change if exposed to air in a moist state, and is, in the presence of alkalies, oxidised; (3) *santalidin*, one of the oxidation products of santalin. It is not so soluble in water as santalin, but it dissolves more freely in the other solvents.

The powdered wood, exhausted in boiling water to remove the brown matter, is digested in a cold clear solution of chloride of lime as long as this becomes coloured. When this is done, it is carefully washed in cold water, and the dye bath is prepared. A hot, but not boiling, solution of carbonate of soda is made. The wood is put into a linen bag, is put into this, and the pan containing it is tightly covered. Heat is applied, but the solution must not boil. When the bath has acquired a bright red colour with a violet tint, it is ready for use.

Woollen, cotton, or linen mordanted in an acid bath are plunged into this decoction of red sanders and worked about until they have acquired the desired shade. They are then returned to the acid mordant. Shades of great brightness are thus obtained. —*Bulletin de la Société Chimique de Paris*, February 5, 1876.

SANITAS. The name given to a supposed solution of peroxide of hydrogen and a camphor. The invention of sanitas will be best appreciated by giving a *résumé* of the researches which have, according to the patentee, led to it. Ever since the discovery of ozone by SCHÖNBEIN, health-preserving powers have been ascribed to its presence in the atmosphere, and tables have been constructed in which it has been attempted to show a certain sort of relation between the absence of ozone and the amount of prevalent disease. This ozone was believed to be partly the result of the action of electricity, but a more popular notion assigned it to vegetation. It was supposed, in short, that plants generally, and particularly oil-secreting plants, possessed the power of so acting upon the oxygen of the air as to cause its conversion into ozone. That an active agent of some kind is so formed there was no doubt; but its true character had never been established, since the tests applied for the detection of ozone did not serve for its absolute identification. Notable among substances giving similar reactions is the body termed peroxide of hydrogen, and it was to this substance that Mr. KINGZETT considered the ozone-like characters of the atmosphere surrounding pine and eucalyptus forests to be due. In the course of his researches[1] this theory has been established.

It is impossible here to consider these researches at all in detail, and it will be best, therefore, to present the main features of them, more especially in their connection with the manufacture of the antiseptic and disinfectant solution termed 'sanitas.' KINGZETT found that when the essential oils of caraway, bergamotte, juniper, lemon, chamomile, turpentine, eucalyptus, &c., and, in short, all those oils which yield a terpene of the formula $C^{10}H^{16}$, are exposed to air in the presence of water, they absorb oxygen and give rise to the formation of peroxide of hydrogen, which then dissolves along with other matters in the water.

In the case of turpentine the reactions by which this effect is produced are as follows:—

$$(1)\ C^{10}H^{16} + O^{3} = C^{10}H^{14}O^{4} + H^{2}O.$$

$$(2)\ C^{10}H^{14}O^{4} + 2H^{2}O = C^{10}H^{16}O^{4} + H^{2}O^{2}.$$

That is to say, an organic peroxide is formed, which, being unstable, is split up by the water into peroxide of hydrogen and camphoric acid. These, however, are not the only reactions that occur. Another part of the turpentine absorbs oxygen and produces camphor by the reaction ($C^{10}H^{16} + O = C^{10}H^{16}O$), and a number of resinous and camphoraceous substances, whose nature is not so well established. These also dissolve in part in the water, along with the peroxide of hydrogen and camphoric acid; and together in solution they constitute the preparation termed sanitas, the manufacture of which will be presently described.

Other natural groups of hydrocarbons allied to the terpenes above named are represented by the formulæ $C^{15}H^{24}$ and $C^{20}H^{32}$. KINGZETT showed that these do not admit of atmospheric oxidation in the way that has been described, and consequently they cannot give rise to the formation of peroxide of hydrogen. It was ultimately found that all hydrocarbons yielding cymene as a proximate nucleus, as also cymene —$C^{10}H^{14}$—itself, give peroxide of hydrogen by KINGZETT's method; and simultaneously with that chemist's observations that the bodies $C^{15}H^{24}$ and $C^{20}H^{32}$ fail to give this product of atmospheric oxidation, WRIGHT and other chemists showed that they also fail to yield cymene by those methods which would give rise to its production were it present as a proximate nucleus in the grouping of their molecules.

Further, in support of KINGZETT's law of oxidation of the terpenes and allied hydrocarbons, he found that menthene, $C^{10}H^{18}$, which gives cymene, $C^{10}H^{14}$, by suitable methods, also gives peroxide of hydrogen when oxidised as described.

Now it will be seen that the method of oxidation employed by KINGZETT is an exact imitation of what occurs in pine and eucalyptus forests. These trees secrete oils containing a terpene, and these volatising into the atmosphere absorb oxygen and give rise to the very same products which may be obtained in the laboratory. A part of the oil is, however, changed by oxidation and otherwise while it yet remains in the trees, and in this way gums and camphors are produced.

Being aware of the disinfecting powers of peroxide of hydrogen, and the antiseptic character of camphor, KINGZETT was naturally led to investigate the properties of that solution, 'sanitas,' which is prepared as described below; and it was found that

[1] *Journ. Chem. Soc.*, June 1874; *ibid.* March 1875; *Chem. News*, vol. xxxii. p. 138; *Pharm. Journ.* September 23, 1876; *Journ. Soc. Arts*, February 16, 1877.

it possessed peculiarly strong powers in these directions. Moreover, as the solution is non-poisonous, and non-injurious to clothing, furniture, and metals, it seemed to fulfil all the conditions of an agent for which a great public demand exists. In conjunction, therefore, with Mr. ZINGLER, Mr. KINGZETT worked out a process by which the oxidation products of turpentine could be rendered available for commercial purposes. This is done as follows:—A number of three-necked earthenware vessels, standing in wooden vats containing water kept by means of steam at the temperature of hot sunshine, are charged with about 80 gallons of water and ten gallons of turpentine, a current of air produced by a blower being forced through the mixture for a period varying from 50 to 100 hours, according to the strength of the product desired. In this way the turpentine absorbs oxygen, and gives rise to the production of hydric peroxide, camphoric acid, and various other camphoraceous substances which dissolve in the water underneath the turpentine, and this aqueous solution constitutes the antiseptic and disinfectant termed sanitas. The air which leaves the oxidisers is charged with turpentine, and this is recovered by causing it to pass in the first place into a box containing water, and finally up and down a number of scrubbers charged with pumice-stone. In this way the turpentine is condensed, and is returned to the oxidisers from time to time.

Along with the sanitas in the oxidisers there is left a quantity of thick, heavy, oxidised oil, and this contains a considerable quantity of undecomposed camphoric peroxide. This may be shown by heating it to the boiling-point of turpentine, when it decomposes and gives rise to a torrent of oxygen. This oxidised oil has the power, therefore, of producing a further quantity of peroxide of hydrogen by slow decomposition in contact with water, and, possessing this character, it is used for making sanitas soap, and also in the preparation of varnishes.

SANSEVIERA. ('The Bowstring Hemps.') Plants belonging to the genus of *Liliaceæ*, so called because the fibres were used in the countries where they are indigenous for bow-strings. See TEXTILE MATERIALS. Consult *The Treasury of Botany*, by LINDLEY and MOORE.

SANTALIDIN. An oxidised product of santalin. See SANTALIN, vol. iii. p. 751.

SAPONIFICATION. M. BIRNBAUM, in the *Bulletin de la Société Chimique de Paris*, gives the following:—

'Fats are saponified industrially either by water under pressure or by dilute sulphuric acid in open vessels. The quantity of neutral fat remaining after industrial saponification is estimated by the quantity of glycerine set free by the action of caustic potash. An indigenous tallow, heated with water for ten hours at fourteen atmospheres, and then saponified with potash, yielded 0·094 of glycerine in 8·355 parts, corresponding to the percentage composition following:—

Water	0·26
Neutral fats	10·90
Free fatty acids	88·57
	99·73

'A grease from New York treated seven hours at fourteen atmospheres, and then re-treated, gave—

	First Treatment	Second Treatment
Water	0·38	0·11
Neutral fats	14·37	13·08
Free fatty acids	85·17	86·11
	99·92	99·30

'The results by saponification are much more perfect, as shown by the following analysis of a grease thus treated:—

Water	0·12
Neutral fats	99·53
Ash	0·03
	99·68

SAPAN WOOD. (*Cæsalpinia Sappan.*) Analogous to the colouring matter of Brazil-wood.

SAPPHIRES AND RUBIES. NEW SOUTH WALES.—The usual forms met with in New South Wales are double-sized pyramids, sometimes combined with the basal pinacoid or other pyramids; the prism is less common. Perfect crystals are, however, rare, the majority of the specimens being either fractured or water-worn. There

appears to be no record of their having been found *in situ*. In certain cases it would appear from their sharp and unworn edge that they had not travelled very far. H = 9. Sp. gr. = 3·49 to 3·59.

The New South Wales sapphires, in common with those from other parts of Australia, are usually rather dark in colour; they, however, are found varying from perfectly colourless and transparent, through various shades of blue and green, to a dark and almost opaque blue. One or two green coloured sapphires or oriental emeralds are almost always met with in every parcel of a hundred or so specimens, also blue and white parti-coloured.

Asteria, or sapphires which show a six-rayed star of reflected light, are by no means uncommon.

Sapphires are almost invariably met with by the miners as an accompaniment of alluvial gold.

They are widely distributed over the New England District, as at Bingera and near Inverell, with tin, adamantine spar, zircons, topaz, and bismuthite; in Vegetable, Cope's, and Nundle Creeks, the Gwydir River, Dundee, Uralla, Ben Lomond; Mann's River; the Abercrombie, Namoi, Peel, and Cudgegong Rivers; at Two-mile Flat, in Bell's River and Pink's Creek, with white topaz, almandine garnets, epidote, spinelle, chrysoberyl, chrysolite, hyacinth, &c.

Artificial Production of Sapphire, Ruby, and Crystallised Silicates. (E. Fremy and Feil.) A fusible aluminate is heated at a bright red heat in contact with silicious substances for a lengthened period, the aluminate is decomposed, a silicate being formed, and the alumina set free crystallises in the bath of molten silicate. The most successful results have been obtained with aluminate of lead. A mixture of red lead and alumina being calcined at a red heat in a clay crucible, gives rise to two products, which are separated into layers. One of these is vitreous, and consists essentially of silicate of lead; the other is crystalline, and often contains druses presenting fine crystals of alumina. In this operation the silica is furnished by the substance of the crucible, which is proportionately corroded or even perforated as the operation proceeds. It is, therefore, necessary to protect the crucible in which the process is conducted by an outer one. The crystals obtained by this method are white; to obtain ruby and sapphire coloured ones, 2 or 3 per cent. of bichromate of potash or a little oxide of cobalt must be added. They are usually covered by silicate of lead, which may be removed either by steeping in melted lead, by hydrochloric acid, by fused caustic potash, or by prolonged heating in hydrogen, and subsequently by the action of alkalies and acids.

The crystals produced are in every way similar to natural rubies, having the same hardness; their specific gravity is 4·0 to 4·1. In polarised light they show the regular uniaxial double refraction of the species.

The same authors have also repeated Deville's experiment of producing silicates of alumina by heating silica with fluoride of aluminium. In this way a mineral representing fibrous kyanite or rhätizite was formed, and with fluoride of barium, a crystallised double silicate of baryta and alumina.

SATSUMA WARE. A creamy white hard earthenware with a fine glaze, composed of felspathic materials and lixiviated wood ash, always minutely crackled, and decorated in enamel colours of great brilliancy. It is produced in potteries near Kagoshima, in the province of Satsuma, where about 1,500 potters are employed in its manufacture.

SCHEELE'S GREEN. (Vol. ii. p. 739; Copper, vol. i. p. 947.) S. P. Sharples affirms that a curious error in regard to this salt has found its way into many of the text-books. Watts, in his Dictionary, states that it is dissolved by an excess of ammonia without colour. In this he is supported by Graham, Otto (last edition) and the *Handwörterbuch*. This evidently arises from a misunderstanding of Berzelius' description (Wöhler's Trans., 1838) of this substance. After describing the preparation of arsenite of copper by means of arsenious acid and the carbonate of copper, he goes on to say:—A neutral combination is obtained, when sulphate of copper is precipitated by means of arsenite of potassium. The precipitate is green. When the alkali is in excess, the colour is brightened; but it decomposes spontaneously after a time, and becomes dark brown, and contains cupric arsenate and cuprous arsenite. This salt is dissolved by ammonia to a colourless liquid, which most likely contains cuprous arsenate. "*This salt*" in the above sentence evidently refers not to the green salt, but to the brown. "That this view is correct," says Mr. Sharples, "is confirmed by numerous experiments I have made upon the subject, and by the following description which is found in Rose's *Qualitative Chemistry*, Paris, 1859, p. 384." Speaking of Scheele's green, the author says:—"This precipitate is soluble in an excess of ammonia and also in an excess of hydrate of potassa; the solution in both cases is of almost the same blue colour. The blue solution

formed by the potash, deposits, after a time, reddish-brown suboxide of copper. The liquid becomes colourless, and contains potassium arsenate. The blue solution formed by ammonia is not modified by time. To this I will add that ammonia does not decompose SCHEELE's green by prolonged boiling: the copper may, however, be completely precipitated as suboxide by the addition of potassa to the ammoniacal solution."—*American Chemist.*

SEA-SOUNDING. *Sir* WILLIAM THOMSON's *Method.*—By the ordinary process of sounding a great weight was required to carry down the line, and an important objection to the latter was the enormous resistance it afforded when great length had to be payed out. It occurred to Sir WILLIAM THOMSON that this might be obviated by using a very fine wire that could be carried down a great length by a comparatively small weight. He had a wire about the thickness of a pianoforte wire made three miles long; but there was some difficulty in getting it made of so great a length, the ordinary lengths being about half a mile. A great objection to sounding with wires only half a mile in length would be the frequent splicing that would be necessary; and rather than resort to this, he preferred waiting a little until a longer wire could be manufactured. He had, he believed, already demonstrated that a 30 lb. weight would be sufficient to carry down a wire of the size referred to a depth of three miles. Hauling the wire in was rather more difficult, and required great care. Ordinary deep-sea soundings were performed with a steam-engine, and it was considered necessary to have an elastic appliance to prevent the rope breaking with the rolling of the ship. No such elastic appliance was required with the steel wire, but simply a drum, with an endless rope passing over a groove on a wheel. The wheel was stationed at the side of the vessel, and back on deck there was a pulley hung on an upright support, around which the endless rope revolved. This pulley was so hung that it moved backwards and forwards as the vessel heaved, and attached to it was a spring that acted as a regulating force. For each mile that was payed out a greater strain was added, so that there was always a greater resistance brought against the wire as it was required. The strain was so regulated that the resistance was continually sustained until the bottom was reached, when it at once ceased, and the sounding was accurately made by the length of the wire payed out. In ordinary soundings the depths could only be judged by taking a note of the time; but by this system the weight went to the bottom and the wire stopped at once. Sir WILLIAM THOMSON had made sure of this already at a depth of 700 fathoms. The weight of the wire out was less than the weight of the sinker, so that about forty pounds of resistance was sufficient to a depth of 700 fathoms. For hauling the wire up he had a ratchet on the wheel, and an exceedingly slight back strain was sufficient; indeed, two men pulling the rope back along the deck were quite able, each pulling at a force of 20 lb., to take it up from a depth of two or three miles in an hour. He thought that they would see that this system really made deep-sea soundings a very easy matter, and the process was very simple. Three things only were requisite: first, to get a suitable wire; secondly, a wheel light enough and strong enough; and thirdly, to measure the force or resistance applied. When Sir WILLIAM began to move on this subject, in May 1872, he was told it was impossible, and that the Admiralty had tried it fifteen years without success. They said he could not handle the wire, and would be unable to prevent it from kinking; but he did not seek to handle the wire, having made that unnecessary, and he had also shown that the appliances used obviated the possibility of the wire kinking. The dynamometer told him when the weight reached the bottom, and the distance was measured very accurately. There was one apparent drawback in the use of the wire. When it had been once in the sea it came up with organisms of all kinds sticking to it, and they carried with them salt water which rusted the wire. To prevent this it was proposed to galvanise the wire, and the wire taken out in the *Challenger* was galvanised; but for more than one reason that was not expected to answer. Even although the wire did rust through, this could be met by carrying plenty with them. The cost would be very small, seeing that it only required 30 lb. of wire to take a three-mile sounding. Mr. JAMES YOUNG, in his yacht, found the use of lime of immense value in preventing rust, and according to his suggestion Sir WILLIAM THOMSON, immediately the sounding was over, put the wire into lime water. As the quantity of salt water carried up by this wire might prevent the lime from percolating it sufficiently soon to keep away the rust, he thought it better to haul the wire up through a trough of lime water, so that the moment the wire emerged from the sea it would be brought in contact with the lime; and by this suggestion of Mr. YOUNG's it is hoped to get rid of the liability to rust altogether.

SEA-WEED, OBTAINING ALKALI FROM. See POTASH.

SEA-WEED, CHARCOAL FROM. See CHARCOAL FROM SEA-WEED.

SEBAH. (*Egyptian Nitre Earth.*) Dr. VOELCKER found this to contain 1·01 per cent. of nitrate of potassium.

SELENIUM. (Vol. iii. p. 760.) An elementary substance which appears to occupy an intermediate place between sulphur and tellurium. It was discovered by BERZELIUS in 1817. It is generally found associated with sulphur. For the mode of obtaining selenium, see WATTS'S *Dictionary of Chemistry*.

Of late some peculiar properties have been observed, which again brings this peculiar elementary body under our notice:—

Mr. MAY, a telegraph clerk at Valencia, noticed that a bar of crystalline selenium, such as had been used for some time in telegraphy where high electrical resistance was required, offered considerably less resistance to a battery current when exposed to light than when kept in the dark. These facts were first made known by Mr. WILLOUGHBY SMITH in 1873.

In March 1873, Lieut. SALE, R.E., communicated to the Royal Society a paper on 'The Action of Light on the Electrical Resistance of Selenium.' Lieut. SALE'S experiments went to prove that the resistance of selenium is largely affected by exposure to light; that this effect is not produced by the actinic rays, but is at a maximum at, or just outside the red rays, at a place nearly coincident with the focus of the maximum of the heat rays; that the effect of varying resistances is certainly not due to any change of temperature in the bar of selenium; that the effect produced on exposure to light is sensibly instantaneous, but that on the cutting off the light the return to the normal resistance is not so rapid. It would seem that there exists a power in rays nearly coincident with the heat rays of high intensity, of altering instantaneously and without change of temperature the molecular condition of this particular element.

Lieut. SALE made some experiments on the effects of the different rays of the solar spectrum on a bar of selenium with the following results:—

(It should be noted that the experiments were made in an ordinary room in diffused daylight, and the spectrum was superimposed on the daylight.)

Resistance of selenium bar in darkness	330,000
" " violet ray	279,000
" " red ray	265,700
" " orange	277,000
" " green	278,000
" " blue and indigo	279,000
" " centre of red	255,000
Resistance just on the outside edge of the red	222,000
Resistance in dark rays clear of red	228,000
Resistance in diffused daylight only	270,000
Resistance taken in dark immediately after exposure (resistance rising)	310,000

—*Proceedings of the Royal Society*, vol. xxi. p. 283.

Professor W. G. ADAMS in 1875 communicated to the Royal Society a paper on 'The Action of Light on Selenium.' The experiments were made—

1. To determine whether the change in the electrical resistance of the selenium is due to radiant heat, light, or chemical action.

2. To measure the amount of the change of resistance due to exposure to light from different sources, and through various absorbing media.

3. To determine whether the action is instantaneous or gradual, and, if possible, to measure the rate at which the action takes place.

The selenium formed one of the four resistances in a WHEATSTONE'S bridge, and its average resistance was about 2½ megohms.

The box containing the selenium was laid on its side, and had a draw-lid which was kept closed except when exposure was made. In front of the draw-lid was a black screen with an opening opposite to the selenium, 6 centimètres by 3½ centimètres, into or in front of which various absorbing media could be placed. The absorbing media employed were bichromate of potash, sulphate of copper, ruby, orange, green and blue glasses. Plates of rock salt, alum, mica, and quartz were also employed.

With the lid of the box on, the resistance of the selenium was measured, and was found to increase slowly and regularly in consequence of heating by the current. In most of the experiments a battery of 30 LECLANCHÉ cells was employed. It was found the higher the battery power the less is the resistance of the selenium. Experiments with 5, 30, and 35 cells gave the following results:—

Resistance R with 5 cells	5,400 ohms
" " 35 "	4,400 "
" " 5 "	5,400 "
" " 30 "	4,600 "

After some hours—

Resistance R with 30 cells	. . . .	4,600 ohms
" " 5 "	. . . . .	5,760 "

(R is taken to represent the resistance required to balance the selenium.)

Exposure to light diminishes the resistance of the selenium. This, says Professor ADAMS, may be accounted for by either of two hypotheses:—

1. That light acting on the selenium sets up a polarisation current in it which opposes the battery current passing through it.

2. That light makes the selenium a better conductor of electricity by producing a change in its surface similar to the change which it produces on the surface of a phosphorescent body, by which that body is enabled to give out light after it has been exposed. Numerous experiments were made by Professor W. G. ADAMS, the results being that—

When first exposed after being closed up for some days, or even hours, the selenium is more sensitive to light. This sensitiveness increases with the time during which the selenium has been kept in the dark; hence the first experiment is not comparable with the others.

On exposure to light the resistance is diminished, but on being again eclipsed, the selenium returns in a very few minutes *nearly* to its previous resistance. The change of resistance produced by exposure to daylight sometimes amounts to one-fourth of the whole resistance of the selenium. Numerous experiments were made by Professor ADAMS with absorbent media, all of which seemed to show that the action is almost entirely due to the illuminating power of the light falling on the selenium. The yellowish-green rays were among the most active in altering the electrical state of the selenium. This is not in accordance with the results obtained by Lieut. SALE.

Many careful experiments were made on the heat radiations, all of which went to show that very little effect is produced by the radiation of obscure heat.

The above hypotheses are suggested as possible explanations which may help as guides in further experiments.

It would appear that an electromotive force is established which opposes the battery-current passing through it, the effect being, as already stated, similar to the effect due to polarisation in an electrolyte.

Professor W. G. ADAMS and Mr. R. E. DAY have more recently communicated to the Royal Society some further experiments on 'The Action of Light on Selenium.' The objects of their experiments were—

i. To examine the character of the electrical conductivity of selenium when kept in the dark.

ii. To determine whether light could actually generate an electric current in the selenium.

Several pieces broken off a stick of vitreous selenium were fastened to rings of platinum wire by heating them. These were then soldered to annealed copper wires. The selenium was then enclosed in a piece of glass tube, the electrodes being passed through corks fixed in the end of the tubes. With this arrangement the experiments were made. From results obtained after a great many experiments made to determine the diminution of resistance with increased battery power, and the change of resistance with a change in the direction of the current, the following conclusions were drawn:—

1. That on the whole there is a general diminution of resistance in the selenium as the battery power is increased.

2. That the first current through the selenium, if a strong one, causes a permanent set of the molecules, in consequence of which the passage of the current through the selenium during the remainder of the experiments is stronger in that direction than it is when passing in the opposite direction.

3. The passage of the current in any direction produces a set of the molecules, which facilitates the subsequent passage of a current in the opposite, but obstructs one in the same direction. Hence, when two currents are sent through successively, after a very small interval, in the same direction, the resistance observed in the second case, even with the highest battery power, is often equal to, or greater than it was before.

The question presented itself, whether it would be possible to *start a current in the selenium merely by the action of light*. Accordingly the same piece of selenium was connected directly with a galvanometer. While unexposed there was no action whatever. On exposing the tube to the light of a candle, there was at once a strong deflection of the galvanometer needle. On screening off the light the deflection came back at once to zero.

The results of numerous experiments proved conclusively the following points:—

1. That pieces of annealed selenium are in general sensitive to light, i.e. that under

the action of light a difference of potential is developed between the molecules, which under certain conditions can produce an electric current through the substance.

2. That the sensitiveness is different at different parts of the same piece.

3. That in general the direction of the current is from the less towards the more illuminated portion of the selenium, but that owing to accidental differences in molecular arrangement, this direction is sometimes reversed.—*Proceedings of the Royal Society*, vol. xxv., No. 172.

When these phenomena were first noticed by Mr. WILLOUGHBY SMITH in 1873, and had been but for a short time studied, a few experiments made with *tellurium* showed that that metal also gave a less resistance under the influence of light, though not to such an extent as selenium. Herr BORNSTEIN has conducted similar experiments with other metals, and has published (1877) the paper he recently read on the subject before the Philosophical Faculty at Heidelberg. He finds that the same property belongs to platinum, gold, and silver, and it is probable to other metals also. The subject is one of practical as well as purely scientific interest.

Dr. WERNER SIEMENS has published some very beautiful experiments, in which the selenium under examination was in a form in which the surface action produced by light can produce its *maximum* effect. Two spirals of thin wire (iron or platinum) are laid on a plate of mica in such a way that the wires lie parallel to one another without touching. While in this position a drop of fluid selenium is made to fall upon the plate, filling the interstices between the wires, and before the selenium has had time to harden, another thin plate of mica is pressed down upon it so as to give firmness to the whole. The two protruding ends of the spirals serve to insert this selenium element in a galvanic circuit. Dr. SIEMENS calls this disc his 'sensitive element.' The whole arrangement is no larger than a sixpence. Its action was shown in this way:—It was placed in a galvanic circuit, at one end being a DANIELL's cell, and at the other a delicate index galvanometer. The 'disc' was first enclosed in a dark box; the circuit was 'made,' but no electricity passed through, no movement of the index was seen. The 'disc' was then exposed to light; still no action was apparent. Another disc was taken that had been kept in boiling water for an hour, and gradually cooled. In the dark box it gave a slight passage to electricity as indicated by the index, but as soon as the light was admitted the index registered a great passage of electricity. Another disc heated to 210° C., and allowed to cool, was then used, and a greater action still was apparent with this. Dr. WERNER SIEMENS has worked at the meaning of this. The basis of the change in condition seems to lie in the fact of the extent to which the selenium is heated, for when again allowed to cool its behaviour depends on the extent to which it has been heated. The experiment was made to determine the effect of different parts of the spectrum on a disc. The actinic ray produces no effect, but the influence increases as we approach the red end. A selenium photometer was constructed, the principle of which is to compare the relative effects of two lights in affecting the conditions for the passage of electricity. A most interesting little apparatus has resulted from this inquiry, which Dr. SIEMENS calls a selenium 'eye.' There is a small hollow ball, with two apertures opposite to each other. In one is placed a small lens, 1½ in. diameter, and at the other a disc. The disc is connected with a DANIELL cell and a galvanometer, and this represents the retina. There are two slides, which represent the eyelids. The action of light on the disc is indicated on the galvanometer. Not only was this proved to be sensitive to white light, but sensitive in different degrees to different colours. Dr. SIEMENS suggests that it would not be difficult to arrange a contact and electro-magnet in connection with the galvanometer in such a manner that a powerful action of light would cause the automatic closing of the eyelids, and thus imitate the spontaneous brain action of blinking the eyelids in consequence of a flash of light. To physiologists this analogy may be suggestive regarding the important normal functions of the human frame.

In the *Transactions of the Royal Irish Academy* will be found a paper read by Messrs. HARRY NAPIER DRAPER and RICHARD J. MOSS, entitled a *Report on the Allotropism of Selenium and on the Influence of Light on the Electrical Conductivity of this Element*. They appear to have proved that fused vitreous selenium shows a great increase of conductivity as the temperature increases, and especially as it approaches 300° C. Their general conclusions were as follows:—

(*a*.) That in thin flat bars of selenium the production of the conducting and light-sensitive form is readily effected by heating for from thirty to sixty minutes at 180° C.

(*b*.) The amount of conductivity increases with the continuance of the heating.

(*c*.) Continued heating does not increase the light sensitiveness.

(*d*.) Selenium cast in a mould is not so susceptible of change into the conducting crystalline form, as is that which has been moulded by hand.

(*e*.) Selenium, rapidly cooled from 160° C., appears to be more sensitive to light than when cooling takes place slowly.

Selenium in a spongy state was thought to be more sensitive than the more dense variety. It has therefore been thought that the conductivity was due to gases or vapours condensed within the pores; but Messrs. DRAPER and MOSS prove 'that selenium in a chemical vacuum is affected by light in the same way as selenium under ordinary atmospheric conditions.'

SELENIUM IN FINE SILVER.—It is a tolerably common occurrence to find, in France, silver bars of a high degree of fineness ($\frac{995}{1000}$ to $\frac{998}{1000}$) unfit for making alloys for medals, plate, or similar ornamental purposes, the standard of which in France is 950 fine. The alloy made with such metal gives spongy and brittle ingots that can only be wrought with great difficulty; the surfaces of the finished work are covered with grey spots, which, although partially removed by polishing, reappear if the article is gilded. When such silver is alloyed with copper there is a considerable amount of ebullition with projection of melted particles, even when the operation is performed, as is usually done, under a covering of charcoal. To establish the presence of selenium in such silver a residue is obtained by dissolving about 1,000 grains of it in nitric acid at 34° Beaumé, precipitating the silver as chloride by hydrochloric acid, and evaporating the clear solution to dryness, when selenic acid is found. This, when treated with a few drops of hydrochloric acid, gives selenious acid, which may be reduced to the elementary condition by sulphurous acid, when selenium is obtained as a black powder that can be readily collected and weighed. If the solution is effected with nitric acid, diluted to 10° or 15° Baumé, grey crystalline lamellæ of a metallic lustre are obtained, which are selenide of silver, a compound which is not readily soluble in weak acids.

The author has determined the presence of selenium in this way in nearly every specimen of silver from bars that had been separated from gold by acid, but he was unable to find it in such as was refined from lead by cupellation. By the addition of 6 grams of selenium to 6½ kilograms of the latter kind of silver when melted, all the bad qualities observed in the metal from separated bars were produced. It is evident, therefore, that a considerably less proportion of selenium than 1 in 1,000 is sufficient to seriously injure the quality of silver for manufacturing purposes; as in the compound made for experiment, a considerable proportion of the selenium added was volatilised.

When seleniferous silver is alloyed with copper, the cause of the boiling observed is due to the oxidising effect of the suboxide of copper invariably contained in the latter metal, upon the selenium. This produces selenic acid, which escapes, and the action, being independent of the air, goes on equally well under a protecting cover of charcoal. The grey spots on the wrought surfaces are produced by the dispersal of scales of selenide of silver through the mass of the metal. The source of the selenium is evidently to be looked for in the impurities of the sulphuric acid used in separating, which is now generally made from pyrites, and is commonly seleniferous. Besides the acid to dissolve the metal, a large excess of it is required to keep the silver sulphate in solution when separating the precipitated gold; and the whole of the selenium that may be present is sure to be precipitated with the silver when the latter is thrown down by metallic copper. It is therefore of considerable importance that pure acid should be used in parting, or else that the resulting silver should be subjected to an oxidising fusion in the air, either alone or with an addition of nitrate of soda, in order that the selenium compound may be destroyed.—H. DE BRAY, *Berg- und Hüttenmännische Zeitung*, vol. xxxv. p. 329; *Abstract Papers of the Institute of Civil Engineers.*

SENARMONITE. See ANTIMONY.

SENECA or **GENESSEE OIL.** A name given to natural petroleum, which in its oleaginous state has long been used as a remedial agent. See VASELINE.

SESAMUM. (Vol. iii. p. 761.) *Sesamum indicum.* A genus of *Pedaliaceæ*, consisting of annual herbs indigenous to the East Indies. Its seeds contain an abundance of fixed oil as tasteless as that of the olive. It is sometimes called gingelly oil.

Surgeon-General CHARLES ALEXANDER GORDON, in his *Our Trip to Burmah, with Notes on the Country* (1876), states that the *Sesamum* grows abundantly, and that its seeds 'are sent from India to England to be used for the preservation of sardines and in the manufacture of the finest "Lucca" oil.' This is not exactly correct. Sesamum seed is expressed in Egypt in great quantities, and much of the oil is sent to Italy for adulterating the ordinary varieties of olive oil. It is, however, so apt to become rancid that it is dangerous to use it in preparing the sardine for the market. This oil is also known as TEEL OIL.

SHAFT SINKING, CHAUDRON'S *Method of, in Water-bearing Strata.* In vol. i. p. 449, article BORING, will be found a description and drawings of the Kind-

CHAUDRON system of sinking shafts, and in the article ROCK BORING, in this volume, several machines are described which have been extensively used in mining, engineering, and quarrying operations.

Mr. HENRY SIMON, C.E., of Manchester, has recently given an excellent description of CHAUDRON'S method of shaft sinking, and having been favoured with a copy of his paper, we give the following extracts from it. The wood-cuts given in the former volume will fully illustrate these extracts:—

By the process worked out and improved by M. J. CHAUDRON, a Belgian mining engineer, no pumping machinery is used, and the water of the strata is not meddled with. The whole operation of sinking and tubbing is, with the help of certain tools and apparatus, done from the surface; not a man descends until the shaft is quite finished, securely tubbed, and absolutely dry. The water remains in the hole all the while, and, so far from being a hindrance or obstacle, is absolutely necessary for the working of the CHAUDRON system, as will clearly appear afterwards from the description. Moreover, the walls or sides of the shaft are supported to a considerable extent by the water remaining inside, whilst under the old system the continued and increased flow of water, induced by the process of pumping itself, loosens the sides of the shaft, thus causing them to tumble in. This system, in fact, is not recommended except when much water is expected. In all other cases the ordinary ways of proceeding, if not quite so certain and efficacious in their results, may be cheaper.

1. *Preparatory Work.*—This consists in the erection of the buildings and sheds which may be found necessary according to the special circumstances of each case; in the erection of the necessary machinery and the preparation of the boring tools and others. The buildings should be arranged in such a way as not to interfere with the ulterior erection of the permanent buildings and winding machinery, &c., necessary for working the shaft when finished. A wooden building, with strong timber frames, will in most cases be sufficient. The power necessary is an ordinary winding engine, strong enough to lift the tools, and to withdraw the spoon or ladle used for extracting the *débris*. For a pit of large diameter, this machine may have a cylinder of 20-inch diameter and 40-inch stroke; the beating cylinder being a simple steam-cylinder open below, and of 3 or 4 feet maximum stroke. It contains a piston of about 30 to 36-inch diameter, the rod of which, passing through top cover of cylinder, is connected to one end of a strong braced timber beam. This beam is supported near the middle, and to its other end the tools for boring, &c., are attached. Steam being admitted by the attendant into the top of the cylinder, the boring tool attached to the other end of beating beam is lifted up, and the exhaust being afterwards opened suddenly, the tool comes down with a force in proportion to its great weight, crushing at each blow part of the bottom of the shaft. The beating cylinder is always and entirely worked by hand. The stroke of its piston is limited by a strong wrought-iron loop attached to the end of a braced timber beam securely fixed in the foundation of engine-house. Between this loop and the beating beam an india-rubber and leather packing is introduced to deaden the blows and noise.

2. *Boring or Sinking the Shaft.*—The process employed during this part of the work is, generally speaking, that which, a good many years ago, was first successfully and repeatedly made use of in the case of borings of large diameter by Mr. KIND, the well-known German engineer and sinker of artesian wells. Four men only are required for this part of the work. The first tool used is a small trépan, or drill, consisting, say, in the case of a pit of about 15 feet diameter, of a heavy solid forging of 7 or 8 tons weight, or thereabouts, according to circumstances, and measures across its lowest and widest part 6 to 7 feet, this being the diameter which it is intended to give to the first boring. This diameter is afterwards enlarged by a greater trépan, which has a weight of, in some cases, up to about 20 tons. The cutting part of the tool must, of course, be greater than the ultimate clear diameter of the pit.

The trépans on their lowest surface are armed with steel chisels or teeth, firmly fixed by keys in carefully-bored holes. Such a tooth weighs up to about ¾ cwt. The outside teeth have a special shape protruding somewhat over the solid body of the tool.

By means of connecting rods the trépan is then attached to the beating beam. Everything is now ready for the work of drilling. The attendant at the beating cylinder admits steam over the piston, thus slowly lifting the trépan through a maximum height corresponding to the stroke of the beating cylinder. On allowing the steam to escape suddenly the tool comes down with great force, crushing part of the surface of bottom. Three men standing on a platform take hold of a lever, before each new stroke, and turn the trépan slightly round its axis, so as to always work on a new line of the surface of bottom of pit. The length of the connections between beating beam and trépan must, of course, be gradually increased as the work proceeds. The first bore-hole made by the small trépan should always be kept ahead of the

larger one by, say, at least 18 to 20 feet. All *débris* detached by the large trépan will thus fall into the smaller hole, and can be withdrawn therefrom by a special tool called 'spoon,' or ladle, which is a wrought-iron rivetted cylinder suspended in a wrought-iron fork, and of a somewhat less diameter than the first boring, so as to allow of its being lowered into it without difficulty. The bottom consists of two flaps, which open upwards when the tool is lowered to the bottom of bore-hole and worked a few times up and down through a short distance by the aid of the winding-engine. They thus allow the *débris*, previously formed by the working of the trépan, to enter and fill the spoon. On beginning to wind up these flaps close immediately, and the contents can be safely landed on the surface. The average progress of sinking by these means varies in ordinary strata between 2 and 4 feet per day.

3. *Tubbing.*—After having bored the shaft to the desired depth and diameter, the next most important operation is the putting in of the tubbing. M. CHAUDRON's tubbing consists of strong cast-iron, entire rings or cylinders having inside flanges at top and bottom, and a parallel strengthening rib in the middle of their height. The total weight of tubbing for a shaft may easily go up to or exceed 1,000 tons, and the very simple and ingenious invention of M. CHAUDRON, for the lowering of this enormous weight, consists in attaching a temporary bottom, in a water-tight manner, to a special inside flange of the lowest ring but one. By this means the ring in question is immediately changed into a vessel, and able to float on the surface of the water in the shaft. Nothing is now easier than to add ring after ring, taking always the utmost care to render all joints absolutely water-tight. Special arrangements have, however, to be made to secure the sinking down of the tubbing, which would otherwise remain floating. This is done by erecting and gradually increasing in length a column of pipes fixed to a hole in the temporary bottom. The pit water, finding its level in this equilibrium pipe, can then be allowed to enter by cocks provided for this purpose, and charge the tubbing to any degree required; care must only be taken not to allow one of these cocks to remain open and sink under the surface of the water level.

To cut off all communication between the inside of the tubbing and the overlying water-bearing strata the shaft should have been sunk to such a depth as to pierce the water-bearing strata by some little distance, and to enter into solid and unbroken ground. On this latter the tubbing is allowed to come to rest, and in order to get a water-tight joint between the outside and the lowest part of the tubbing and the surrounding rock, M. CHAUDRON conceived the idea of giving to the lowest ring the construction of a gigantic stuffing-box. This consists of an outer ring, having at its lower end an outside flange, inside which, and loosely suspended by bolts, is a ring of less diameter, likewise provided at its lower end with an external flange. These two external flanges confine a space which, before the introduction of the stuffing-box into the pit, is filled carefully with moss or a similar material, retained by thin thread or wire-netting. As soon as the tubbing touches its ultimate resting-place at the bottom of the pit, the whole of its enormous weight is gradually allowed to compress the moss in the stuffing-box, and thereby immediately, and for once and all cuts off the water from the upper strata.

4. *Cementing.*—In order to still further secure the permanent tightness of the tubbing, and in order to support it completely and all round, the space remaining between its outside and the wall of bore-hole should now be filled up with concrete or mortar. This operation is executed with the help of a special tool.

5. *Withdrawing the Temporary Bottom.*—In order to do this it is necessary to extract the water inside the tubbing. This should, however, not be attempted until the cement outside has had full time to settle and harden. It is easily and quickly done by a bucket, and by the help of the engine previously used for the sinking. The next operation is the removal of the equilibrium column and of the temporary bottom to which it was attached. The joint made by the moss box can then, if desirable, be supported and secured by further precautionary work, such as the introduction of a wedging crib and masonry. After this the application of CHAUDRON's system is at an end, and sinking and mining operations are begun in the ordinary manner.

The full advantages of CHAUDRON's method can only be available in cases where the quantity of water expected is large, and when the geological section is well known. It is essential, therefore, that previously to commencing a shaft by the CHAUDRON method, borings should be made by the use of the diamond drill, or by some other familiar rock-borer, and a careful register kept of all the strata passed through. If any shafts have been sunk in the neighbourhood, and good sections can be obtained, this is, of course, unnecessary. A sinking made by this system is now (1878) in full and successful operation near Hednesford, in Staffordshire.

SHERRY, ADULTERATION OF. See WINE.

SHUMACH or **SUMACH.** See SUMACH (vol. iii. p. 965.) The importations of shumach in 1875 and 1876 were:—

	1875		1876	
	Tons	Value	Tons	Value
		£		£
From Italy	13,266	225,178	11,851	202,240
„ Australian territories .	738	9,946	449	6,022
„ other Countries . .	682	11,219	497	6,991
	14,686	246,343	12,797	215,253

SIDERAPHTHITE. A name given to a new alloy to which SCHMITTS has called attention. It is said to resist sulphuretted hydrogen; is not attacked by vegetable acids; and mineral acids have but a feeble action thereon. It consists of iron, 66 parts; nickel, 23; tungsten, 4; aluminium, 5; copper, 5. This new alloy, or 'inoxidisable iron,' can replace those metals or alloys which it is necessary to protect with silver plating.

Another alloy, also said to be unalterable, has been formed by the same metallurgist. It is a mixture of copper, platinum, and tungsten, which is fused together and then granulated by pouring into water containing ½ kilo. of slaked lime, and ½ kilo. carbonate of potash per cubic mètre, fusing again, and casting into ingots. It resembles gold 750 fine.

SILICA, REACTION OF, IN BLOWPIPE FLAME. It is well known that most silicates when fused with phosphor-salt are only partially attacked, the bases as a rule gradually dissolving in the flux, whilst the silica remains in the form of a flocculent opalescent mass technically known as a 'silica skeleton.' The latter reaction was regarded by PLATTNER as especially due to the presence of alkalies or earthy bases. See PLATTNER, *Probirkunst*; also *Auflage*, p. 468.

Professor E. J. CHAPMAN writes:—'It is true enough that silicates in which these bases are present exhibit the reaction; but as other silicates, practically all indeed, exhibit the reaction also, the inference implied in the above statement is quite erroneous. The opalescence of the glass arises entirely from precipitated silica.

'If some pure silica (or a silicate of any kind) in a powdered condition be dissolved before the blowpipe flame in borax until the glass be saturated, and some phosphor-salt be then added, and the blowing be continued for an instant, a precipitate of silica will immediately take place, the bead becoming milky (or, in the case of many silicates, opaque) white on cooling. This test may be resorted to for the detection of silica in the case of silicates which dissolve with difficulty in phosphor-salt alone, or which do not give the pronounced 'skeleton' with that reagent.'—CHAPMAN on *Blowpipe Reactions*.

SILICA SKELETON. A flocculent mass left when some silicates are treated with the blowpipe. Professor CHAPMAN, in a note to his paper, *Blowpipe Reactions*, quoted above, asks, 'By whom was the formation of a "silica skeleton" first made known?' He answers his own question by saying: 'It is not mentioned in VON ENGESTROM'S treatise attached to his translation of CRONSTEDT'S *Mineralogie* (1770). BERGMAN alludes to silicious earth and the action of microcosmic salt on it, but makes no mention of the "skeleton." The reaction appears to have been definitely pointed out by BERZELIUS in his standard work on the blowpipe published in 1821.'

SILICATE COLOURS. The use of silica colours has been practised for some years. They were especially used at Munich, and after many years they were found to be unaltered. We learn that occasionally an efflorescence of the silica salt employed appeared upon the surface of the wall-pictures, but this was readily removed without in the least interfering with the colours beneath it. In the article, STONE, ARTIFICIAL (vol. iii. p. 913), and that on STONE PRESERVATION (p. 919), will be found the descriptions of the processes used for the preparation of silicate of soda and potash. We learn from an article in the *English Mechanic* that the silicate paints which have stood so well at Munich contained both potash and soda, and were prepared by melting together 5 parts quartzose sand, 3 potash, and 1 soda. The solution of this 'glass' was found to have a specific gravity of 1·12, a milky appearance, and, when allowed to stand, carbonate of lime was precipitated. The lime was traced to the use of a silicious sand containing infusorial remains, which was boiled in a potash-lye containing a small quantity of soda. The composition of the fresh solution was found to be 65·14 silica, 25·64 potash, 9·22 soda. When the colours were added the 'paint' had a thick consistency, but on the addition of water and the use of the filter, a separation was effected, the solution then showing the following

composition—61·70 silica, 29·05 potash, and 9·15 soda—a change of proportion due to the action of the carbonic acid of the atmosphere in precipitating the gelatinous silica. It is therefore necessary to preserve the solution from atmospheric influences as much as possible, and to mix only as much as can be used at one working. The choice of pigments is limited, so far as present experience goes, but there is still considerable diversity of tint available. At Munich the white was composed of oxide of zinc and sulphate of barytes, the black of peroxide of manganese and lamp-black; while the ochres furnished perfectly innocuous yellows, reds, and browns. White lead must not be used—in fact, it sets too quickly; vermillion becomes too dark when exposed to light, and pigments of organic origin generally should be avoided, as, sooner or later, they fade. The pigments, finely ground, are simply mixed with a portion of the solution, and afterwards diluted with a quantity sufficient to admit of the application of the 'paint' with an ordinary brush. In preparing the glass care should be taken that the soda is not in excess—in fact, it is better to err (if it be an error) by using too little, as soda is liable to produce efflorescence in the shape of a white film, which, though generally removable by means of distilled water, is evidence of a weakness promising premature decay. The preparation of the wall surfaces is one requiring some little degree of care. All holes should be filled up with well-tempered mortar, and the plaster surface be well rubbed down with a piece of sandstone and water. When thoroughly dry, it is usual to go over with a thin coat of the silicate solution before laying on the colour, but it is not absolutely necessary, and sufficient time has not yet elapsed to test the relative advantages attending any of the different systems of working.

SILICATE COTTON. When a strong blast of steam or of air is forced into the stream of viscous slag as it flows from the blast furnace, a finely-divided silicious thread is formed, resembling the fine glass thread made by the glass blower, and which is known as spun glass. See COTTON SILICATE, and SLAG.

SILK IN AUSTRALIA. Mrs. SARAH F. NEILL has been zealously endeavouring to introduce sericulture into Australia, and has established the AUSTRALIAN SILK-GROWERS' ASSOCIATION. We cannot serve this cause more effectually than by allowing Mrs. NEILL to tell her own tale, which she has most ably done in the following letters printed in the *Times* newspaper, May 29, 1877:—

'Before giving any details of the movement that has lately started in Australia for the introduction of a new industry, sericulture, I wish to call attention to the efforts that have been made by Mr. C. BRADY in Sydney, Mr. S. DAVENPORT in Adelaide, Mr. COOTE in Queensland, and Mr. BAILES in Western Australia, to acclimatise various races of silkworms. Mr. BRADY was particularly fortunate, and the Western Australian cocoons were considered quite equal to the Victorian.

'After various trials on the Murray, and armed with letters to Her Majesty's Consuls, kindly granted to me by Lord CANTERBURY, the Governor, I left Melbourne in December, 1871, to search Europe for a race of healthy silkworms, and arrived at Malta in February, 1872. The following months were passed in exploring Sicily, Northern and Southern Italy, the Plains of Lombardy, and the far-famed Novi districts; but nowhere in Italy could grain (eggs) so sound and healthy be found as to warrant expectation in the new and promising mulberry fields of Australia. Leaving Italy I proceeded to traverse the silk districts of France from Nice to Lyons, including the celebrated Cevennes; everywhere I obtained similar information, and found a similar state of things. On receiving some fine cocoons from Spain my attention was attracted to that country; but I found the races were in no healthier state than those of Italy and France. The same information came to me from the Levant. Disease had spread over all the famous countries of the Mediterranean.

'I returned to Milan, and after 15 months' incessant trouble and travel, I was about to give up a search which had proved equally laborious and vain. But from small accidents great results have often been achieved. While changing my notes at a banker's in Milan I noticed a small pill-box on the table, and enquiring as to its contents, I was informed by its owner that in it lay some of the only healthy European grains to be had, and brought from the establishment of M. ROLAND, in Switzerland. Again my drooping hopes revived, and I at once started for Switzerland. Following in the footsteps of Dr. CHAVANNES, M. ROLAND had for years made experiments in the cultivation of silkworms on the open-air system, and there at the foot of the Jura in 1872 I obtained a supply of healthy and fine grain, such as I had long desired to possess. I conveyed this precious treasure to Australia in the following November, aided in my endeavours by the PENINSULAR AND ORIENTAL COMPANY, who supplied me with the ice requisite for the production of an artificial winter in tropical waters, so as to reverse the seasons when in the Southern Hemisphere. Though the Australian summer was far advanced when I arrived, the grain was hatched out most successfully, and in March following I was enabled to despatch a sample of cocoons

to the Vienna Exhibition. The cocoons were awarded a diploma of honour, being too late for a medal. Thus was the Brianza race of silkworms established in Victoria, and a small supply of grain is now sent out every year from Switzerland.

'A word concerning the mulberry tree, which is as necessary for the silk as for the worm itself. The soil of Australia is pre-eminently suited for the growth and abundant foliage of this tree, and the climate from its dryness leaves nothing to be desired. The long summer, lasting from October to May, assures an abundant supply of leaves for successive harvests, while both trees and worms are comparatively free from the unseasonable spring frosts of Europe. On a calculation of the plantations which are known to me, I believe the number of young trees now growing in Australia to be about 1,000,000. The tree was first imported to Australia from this country by the early settlers; later importations were made from the Cape, France, and Italy, and by the kindness of Messrs. Bright Brothers, I was enabled to obtain from Shanghai 1,000 plants of the celebrated Thou (Tu) variety, so named from the Chinese god Tu, and in November, 1872, the well-known Mr. Rawdon Brown, of Venice, sent me 120 of the White Veronese mulberry trees. Strange to say, in 1772—just 100 years before—the Inquisition of Venice issued an edict forbidding, under severe penalties, the exportation to the British Colonies of anything connected with sericiculture. It now remains to speak of those who are to do the work of education. The providing of work suitable to women is, and will be, as necessary in the Antipodes as it is at home, and I must state that, next to the profitable establishment of silk culture in Australia, the employment of poor gentlewomen was my chief aim at home and in the colonies. Two reasons suffice: women are suited for the work, and the work is admirably suited for women. On these considerations, and with a view to enlisting as many as possible in my enterprise, I, in conjunction with eight other ladies, organised the Victorian Sericultural Company (Limited). To this company the Government of Victoria gave 1,000 acres of land, part of which has been planted with the best varieties of mulberry, and on which a large silk house and suitable buildings have been erected. I am receiving the warm support of many ladies of influence who have taken shares.

'The quality of our silk has obtained the highest testimonials from Continental experts, and this week I have received a letter from an eminent French firm urging that steps should be taken for the immediate exportation of cocoons, and saying that they could now offer 24f. to 25f. per kilo. for properly desiccated cocoons, or 100f. to 110f. per kilo. for reeled silk of such a quality as the sample sent from my farm on the Murray. Of course the price depends on the market, but the spring sales are expected to be equally advantageous. As the superiority of our raw material becomes generally known, and its consequent commercial success becomes established, I feel sure that we shall receive more and more abundantly the support which I now solicit. I feel truly gratified for the warm interest already taken in the matter by English ladies, and I can assure the shareholders, present and prospective, that although much assistance must necessarily be rendered by man, there is no danger of the shares being sent up or down the markets by the syndicates of the Stock Exchange.

'After so long a letter I can only refer to the little depôt in Charles Street, Grosvenor Square, where the refuse silk yarns are being worked up into useful articles, and to express the gratitude we owe to Mr. Brocklehurst, M.P. for Macclesfield, for his kind consideration in replying to our many troublesome queries, and for his valuable advice and assistance in enabling us to bring our experiments to a successful issue. I also wish to thank those who have kindly contributed mulberry leaves for the magnificent black worms now being cultivated, and to say that we shall require them in London until the leaves turn yellow, in order to rear all we can.

'From the cocoons now spinning I consider that silkworms of this valuable black race can be reared profitably next year in England for grain.'

Silk in Italy. *Artificial Hatching of Silkworms' Eggs.*—A very curious discovery has been communicated by Suasi, an Italian scientist, to the French Society of Agriculturists, to the effect that the hatching of silkworms' eggs may be artificially hastened by friction. The process consists essentially in brushing the eggs vigorously for ten or twelve minutes with a moderately hard brush, made, preferably, of coarse grass. In less than fifteen days the eggs thus treated will hatch out, with a product as healthy as that obtained in the usual way. A small proportion of the eggs may prove refractory to this novel treatment, and yet in the spring even these will hatch out earlier than those which have been left to themselves.

Suasi performed a series of experiments upon about four-fifths of an ounce of silkworms' eggs, beginning on August 1. They were brushed for ten or twelve minutes daily, and only about one-tenth of the whole number were lost. The first hatchings occurred on the 14th of the month, and were succeeded by others for seventy-two consecutive days, the largest number hatched on the ninth day following

August 14 giving 112 worms. After this date the hatchings decreased. From August 17 to September 1, 932 worms were hatched out. From August 14 to November 14, 1,200 were born. Those which came out during the first fifteen days were raised, and prospered perfectly, although it was found that the worms earliest hatched were not by any means the healthiest. No satisfactory hypothesis has yet been proposed to account for the curious effect thus produced by friction upon these eggs.

Silk Manufacture in Florence.—The statistics of the yield of cocoons published by the Government are incomplete and unsatisfactory. It may therefore be sufficient to state that the average sales of cocoons on the public markets of this province (Florence) from 1854 to 1858 (before the invasion of the silkworm disease) amounted to 21,759 myriagrams, of a total value of 1,257,973 lire; between 1859 and 1863 the average was reduced to 10,870 myriagrams, worth 640,826 lire; while the four years, 1870–73, the average sales on the same markets appeared to have been 22,310 myriagrams, of the value of 1,014,044 lire. The silk husbandry is continually on the increase, and the markets are becoming yearly more important.

The sales on the public markets do not include the whole of the province, as the sales by private contract have also to be considered. The above averages will serve to show, however, how the ravages of the disease are being overcome by the care of the silk cultivators of this province, among whom Count A. Castracane may be especially mentioned for the attention he has paid to microscopical selection, and for his gratuitous services in spreading a right knowledge of the subject among the people. The lower value of the cocoons for the period 1870–73, as compared with the five years 1854–58, may be attributed to the large proportion of Japanese cocoons, which are of inferior quality to the native breeds which formed the earlier yields. These later have, however, been preserved, to a greater or less extent, during the whole course of the disease, and are now beginning to recover lost ground. The disease having spread to Japan, efforts in this direction are rendered the more necessary.

The mulberry cultivated in the province of Toli is the *Morus alba*, of which there are many varieties. Planted in the preceding June, the young trees are disposed of the following spring by the market gardeners (to whom this industry is confided) to the farmers, who plant them in a nursery commonly termed the *boschetto*, at from 60 to 100 centimètres distant from each other. The seedlings are kept in the nursery for three or four years, when they are definitely transplanted to their proper place along the sides of the fields. The trees stand in line, at a distance of from 6 to 7 mètres from each other. They are generally all grafted. In May, after the worms are reared, the trees are carefully pruned, but are not polled, as is usually done in North Italy, a practice condemned in this province.

Generally throughout the province the silkworms are bred by the *metayer* on the farm; the farmer provides all the utensils required, as well as the labour, while the proprietor purchases half the eggs and half the leaves required to feed the worms, if the farm does not produce a sufficient quantity. When the cocoons are sold, the profits are equally divided between the two. In some parts in the neighbourhood of Forli, for example, should the proprietor prefer selling his leaves to rearing silkworms, he forbids the *metayer* to keep the latter, and sells the first to his own exclusive profit. Elsewhere, as at Meldola, a neighbouring commune and an important centre of the silk industry, the profit from the leaves is equally divided between landlord and farmer.

A small factory for the production of damasks and 'gros de soie,' as well as of linen cloths, plain and damasked, with nine Jacquard and twenty Piani looms, has been established at Forli by Mrs. A. Ricci; thirty-five workwomen are usually employed.

Venice.—The crop of cocoons in 1876 was very scarce, and from the beginning of the month of June very active silk business was concluded at about 60 lire per kilo., but at the end of the month the prices rose to about 100 lire per kilo.

Notwithstanding a large supply of silk imported from the East, which produced a temporary stagnation, the prices continued to rise, and at the end of the month of August first quality silk was sold at 130 lire per kilo. European silk when manufactured being lighter than Asiatic, the price of the former reached on September 6, 144 lire per kilo.

In December 1876, however, on the 17th of the month the price of raw silk was 117 lire per kilo. (4*l*. 6*s*. 8*d*.).

In 1875 the crop of cocoons in Venetia and the Tyrol was 673,000 kilos., whilst in 1876 it was only 238,600 kilos., being therefore a diminution in 1876 of 434,030 kilos.

The exports of silk and manufactures of silk from Italy to England during the five years ending December 31, 1875, were, according to Mr. Mallet's *Report* to Sir A. Paget, as follows. This is given in values per 1,000 francs:—

1871	5,005
1872	4,405
1873	2,895
1874	5,256
1875	5,312

SILK IN INDIA.—From ALLEN'S *Indian Mail* we gather the following information respecting the production of silk in India:—

'Two centuries ago silk was raised in Gujarát, and so late as 1829 Dr. KENNEDY saw the process of silk manufacture in that province. The attempt to cultivate silk in Bombay was made by Dr. SCOTT in 1835; but, somehow, the results were not encouraging. Some years afterwards Signor MUTTI took up the question, with the sanction of the Bombay Government, and his earlier experiments promised well. Mulberries were thickly planted in many parts of Bombay, and strong hopes were entertained that the plants would thrive, and that native cultivators would grow mulberry trees sufficient to feed a large number of worms, the silk of which would equal the best of the Italian sort. But before long Signor MUTTI fell ill; the success of his experiments was called in question, and their ultimate failure was ascribed by his successor, Mr. RAMOS, to the adoption of the "standard" in preference to the "bush" system of cultivation. From 1849 to 1858 the silk industry on that side of India made no way at all. At last Dr. BIRDWOOD proposed to utilise the wild worms to be found in many districts, but nothing then came of his recommendations. It was not till 1865 that a really successful experiment was made by Dr. MACKENZIE, superintendent of Dharwar Gaol. As far back as 1843 silk had been cultivated in the Dharwar district with such success that 272 lb. of silk, worth 500r., had been turned out by natives, while 144 lb. produced by the prisoners had been sold at the rate of about 5s. a pound. Between June 1868 and September 1869 the gaol produced 10 lb. 14½ ozs. of raw silk, valued at 8r. a pound, from 145 lb. 10 ozs. of cocoons. In the latter part of this period there was a marked increase in the weight of the cocoons and the percentage of silk to weight; an improvement which Dr. MACKENZIE ascribes to greater care and regularity in feeding the worms, to improved ventilation, and dry well-lighted rooms kept at an even temperature. Samples of the silk were forwarded to Messrs. POLLOCK, silk manufacturers, at Glasgow, who declared them to be of much stronger and better texture than the Bengal silks. It seems certain that Dharwar, with its equable climate, is no less suited for rearing silkworms than for growing cotton, and the excellence of its cotton is already beyond dispute.'

Although the importations of silk from Asia were larger than in former years, yet as the general crop was very scarce in 1876, not only in Europe but also in the countries of the East, there is every reason to suppose that after the settling of the Eastern Question the price of European silk will again rise.

Silk Imports and Exports.—The following represents our import and export trade in silks in 1875 and 1876:—

IMPORTS.

	1875		1876	
	Cwt.	Value	Cwt.	Value
		£		£
Knubs, or husk and waste . .	33,787	415,095	29,863	406,051
Raw silk	4,487,837	3,443,722	6,061,927	5,770,341
Thrown silk	110,010	102,734	164,040	199,293

Silk Manufactures.

	1875 Value	1876 Value
Of countries out of Europe	£246,200	£260,331
Of countries in Europe: Broad stuffs, Silk and satin . . .	7,070,716	6,999,576
Velvets (plain or figured) . . .	1,084,404	827,608
Ribbons	1,989,410	1,718,051
,, (other kinds) . . .	154,367	75,035
Plush for making hats . . .	21,800	51,507
Manufactures of silk, or of silk mixed with other articles (unenumerated) . .	1,697,626	1,583,743

EXPORTS.

	1875		1876	
	Yards	Value	Yards	Value
		£		£
Silk, thrown (twist or yarn)	—	—	—	1,080,078
Silk manufactures . . .	1,937,429	306,441	2,012,810	473,227
Handkerchiefs, &c. . . .	—	346,669	—	319,813
Ribbons of all kinds . . .	—	182,309	—	201,654
Lace	—	137,516	—	196,905
Unenumerated	—	412,318	—	332,891
Silk and other materials .	1,717,231	196,495	1,330,927	174,820
Other kinds	—	92,871	—	98,256

SILKS, BLACK, WEIGHTED. M. J. PERSOZ has examined these silks with great care. The weight of silk was first increased to a very limited extent, to make up the loss sustained in ungumming, but it has increased to the extent, in some instances, of 300 per cent. In the *Moniteur Scientifique*, PERSOZ states that the weight is produced by treatment with salt of iron and astringents, with salts of tin and the cyanides. The bulk is augmented proportionally with the weight; what is sold as silk, he says, is a 'mere agglomeration of heterogeneous matter, devoid of cohesion, held temporarily together by a little silk.' The elasticity and tenacity of the silk are sensibly diminished. Ordinary silk is sparingly combustible, but this weighted silk burns like tinder if touched with flame, and it is liable to undergo spontaneous combustion. It leaves an ash of oxide of iron exceeding 8 per cent.

SILVER ALLOYS. *Comportment of Certain Alloys of Silver under the Action of the Blowpipe.*—*Silver unites with tin* under the action of the reducing flame into a malleable globule, and also with *lead* and *thallium*; with *bismuth* the globule is brittle. Silver unites readily with copper and gold, forming malleable globules.—CHAPMAN.

SILVER AMALGAMATION. Mr. W. SKEY, who has been pursuing a line of inquiry which bears strongly on the separation of the precious metals from the gangue, or from the other ores with which they may be associated, has ascertained the following facts:—

1. Pure silver, when immersed for a few hours in pure water, does not amalgamate immediately; 2, such effect is not produced with rain or spring water; 3, silver modified by distilled water is brought back again to the amalgamable state by contact for a short time with rain or spring water, also with acetic acid or sulphate of iron, and by raising the temperature to 500° Fahr.; 4, electric currents are generated by silver in saline water free from chlorides, iodides, or bromides; 5, silver does not pass into this non-amalgamable state in *dry air*; 6, spongy silver immersed in an aqueous solution of chloride of sodium, soon renders it very alkaline. (Qy.—Is there any evidence of the liberation of chlorine?—ED.). Sunlight exerts no effect in any of the above reactions.—*Transactions and Proceedings of the New Zealand Institute*, 1876.

Chilian Amalgamation Process.—At vol. iii. p. 802, will be found a detailed statement of the Mexican amalgamation process; and at p. 807 of vol. iii. the Washoe process, which is largely carried out in the silver works of Nevada, is described.

The discovery of large deposits of chlorides, iodides, and chloro-bromides of silver in Chili, rendered necessary a process more rapid, even if less perfect. The ores were ground finely, and the powder carried by a stream of water into sheet-iron settling tanks, two mètres wide and three deep, which were filled successively. When full, they were allowed to settle for eight to ten hours, in order to ensure perfect subsidence of the mud. The water was then run off and the sediment carried into *tinas*, or wooden vats, with cast-iron bottoms 1·8 by 1·2 mètres. In each of these revolved an axis with cast-iron arms, which pass close over the bottom of the vat. The charge was $1\frac{1}{2}$ ton. The ore was a mixture of chloride, iodide, and bromide of silver, and the gangue carbonates of lime and baryta with oxide of iron. Mercury was then added to twenty times the weight of the silver present. The stirrer revolved four times in a minute. The amalgamation was complete in twenty hours. Water was then run in, and the stirring continued. The mud was run into settling tanks. When the water became clear an orifice was opened, and the mercury and amalgam run into iron vessels called *cochas*. The amalgam was filtered through thick cotton, and afterwards distilled. Labour, loss of mercury, and other expenses amounted to £1 1s. 8d. per ton for ores containing less than 50 parts of silver in 10,000. An entire operation, including grinding the ore, lasted sixty hours. The *relaves*, or

residues, washed away by the water contained 8 to 10 of silver in 10,000, and never exceeded 20 even in rich ores. The silver contained 1 per cent. of impurities.

In course of time the method changed. The amalgamation lasted six hours—not including the washing. Ores containing only 30 silver in 10,000 came into working. The quality of the ore varied, the proportion of sulphides increasing as the veins were followed to greater depths. The *relaves* grew richer, and the yield of metallic silver less, whilst vast heaps of poor residues accumulated near every mine, to which were added the *desmontes* or inferior matter left out in sorting. Various methods were tried for extracting the silver from these *relaves*. The Freyberg method of roasting and chloridisation was tried, but without good results. Chlorinisation followed by ammonia was also a failure, partly from the high price of ammonia. At last an attempt was made to adapt to these ores the sulphate of copper process, which had previously been confined to the *negrillos*, or rich black sulphides. It is based upon the following reactions:—Sulphate of copper in presence of common salt becomes chloride of copper:—

$$CuO,SO^3 + NaCl = CuCl + NaO,SO^3.$$

The chloride of copper in contact with the metallic copper of the vessels employed became subchloride of copper, which, in presence of sulphide of silver and mercury, reacts upon the sulphide of silver:—

$$AgS + Cu^2Cl + nHg = AgHg + CuCl + CSu + (n-1)Hg.$$

The reaction was performed with great loss of mercury, and the copper vessels were soon destroyed. The first step towards improvement was to form subchloride of copper by other means. Common salt was dissolved in water to the extent of 5 per cent. This solution is known as *saumure*, and is used in amalgamation. Sulphate of copper is dissolved in water up to 20° B., and common salt added to saturation, forming thus chloride of copper. This is next put into a wooden vat, and metallic copper added, chiefly old sheathing from the bottoms of ships. A current of steam at a pressure of three atmospheres is next driven in to boil the liquid. At 212° Fahr. chloride of copper reacts upon the metallic copper, forming subchloride of copper. This reaction is known to be complete when, on taking up 60 cubic centimètres of the solution and diluting with a litre of water, the oxychloride of copper falls as a white powder, leaving a perfectly colourless solution. It must be used immediately, and protected as much as possible from contact of the air, which would convert it into the insoluble oxychloride. To prevent this change it is slightly acidulated with sulphuric acid.

The ores are first powdered in the *tapiche*, an apparatus like an oil mill. Two vertical wheels, each weighing four tons, faced with wrought iron or steel, revolve on a disc called *solera*, made also of iron or steel, upon which the ore is spread. They make ten or twelve revolutions per minute. The ore is ground to fine dust, which is carried off by a stream of water as fast as it is formed. The quantity of water is proportioned to the fineness of the powder desired. The current of water passes successively into several tanks and runs clear from the last. When the first is quite full it is allowed to stand to settle for eight hours. The mud is then shovelled out and spread on level spaces called *canchas* and let dry in the air. Each settling tank is three mètres wide at top, two at bottom, and four deep.

The ore, when dry, is put in casks holding from one to four tons. The latter size are 1·8 by 1·5 mètre, and the staves 0·075 in thickness.

The charge is four tons of ore, with saumure enough to form a thick paste. Magistral is added according to the richness of the ore and the nature of the gangue. When this is calcareous more is needed than for clay and iron, the lime decomposing part of the subchloride of copper. For ores containing 20 parts of silver in 10,000 with a mixed gangue, 28 to 30 litres of magistral are used. The casks are turned 20 to 30 minutes, then the mercury is entered, to 20 or 25 times the weight of the silver present. The casks are then turned for six hours, four or five revolutions per minute. If much chlorine and bromine are present, 100 lb. of lead are added for each 25 lb. of mercury. This prevents chlorinisation of the mercury, as the chlorine and bromine go to the lead in preference. Loss of mercury is thus avoided, as also its fine subdivision by means of thin pellicles of chlorides, which prevent it flowing together. The loss is thus reduced from 150 to 25 parts. The washing is performed as at Freyberg. The amalgam has still to be purified from oxide and sulphide of copper. This also is done in a *tina*. The amalgam is charged in a vat with 10 per cent. of mercury and stirred sixteen times in a minute. The sulphide and part of the oxide are separated. This operation is finished when the water flows out clear. Then the water is run out of the vat and 2 per cent. of carbonate of ammonia added. It is turned from four to five hours and then washed, when the amalgam is found free from copper.

The amalgam is distilled *per descensum*. The furnace is a cast iron bell with its

bottom plunged in water to condense the mercury. The upper part is surrounded with a wall to support the fuel, having a space 8 to 12 centimetres in width.

The spongy silver (*piña*) is fused in a reverberatory furnace. It is well rabbled with iron tools, which removes the arsenic. The silver then contains 98 per cent. of pure metal. The process is applicable to all ores except argentiferous galenas and copper pyrites and blendes and ores containing more than 1 per cent. of arsenic.

The materials operated upon are *relaves* containing 4 parts of silver in 10,000 and ores containing 6 in 10,000. The residues contain from 1·5 to 2.

The mercury, after being used four or five times, has to be purified by adding 20 grams of sodium amalgam to 100 kilos.

SILVER. (Vol. iii. p. 801.) *Chilian Method of Sampling Silver Ores.*—By the plan which is followed in Krohnke's Amalgamation Works in Chili and Bolivia, as well as in the principal mines of the desert of Atacama, the ore is piled and

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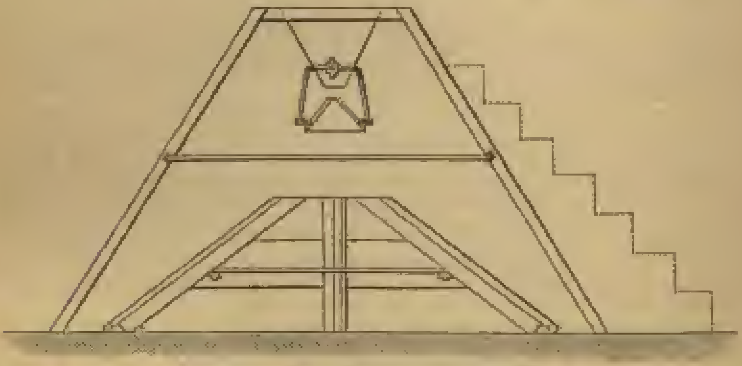
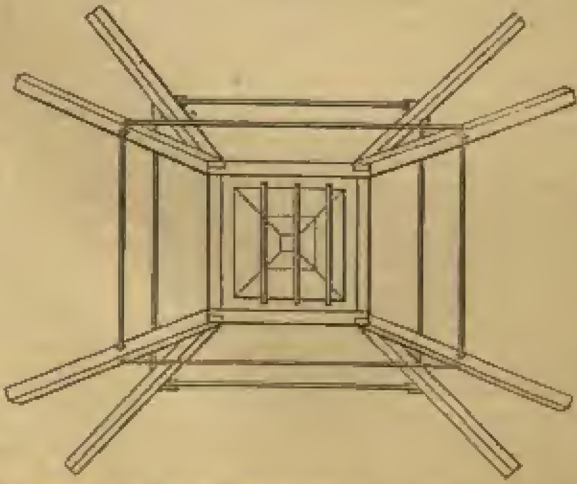


divided into four or more portions at one operation. The apparatus employed consists of a sheet-iron hopper supported on four inclined legs, braced together by horizontal tie rods, below which is suspended a bell or pyramid that can be adjusted by screws so as to be exactly concentric to the bottom of the hopper. Below the bell is

2527



placed the sampling frame, a four-armed rectangular cross of boards, whose outer edges are inclined at 35° to the horizon, or about that of the natural talus of the broken ore. This cross is made in three pieces, and tied together by iron rods when

in use. The ore thrown in at the top passes over the sides of the bell, is distributed uniformly into the four divisions formed by the cross, any one of which may therefore be accepted as a fair representative of the whole. With a cross 6½ ft. high, the heap cubes about 400 ft., equal to about 20 tons. Care must be taken to keep the stream of ore fragments as continuous as possible, but when this cannot be done the bags of ore are emptied alternately on the four sides of the hopper, for which purpose a staircase, shown in the dotted line, is placed on each of the four faces. When the quantity of ore to be sampled is very large, intermediate walls are sometimes used, dividing the heaps into eighths. The selected quantity, whether one-eighth, one, or two quarters, is then passed through a similar apparatus of smaller dimensions, and the next selected quantity a third time, when two rectangular iron boxes, placed crosswise, are substituted for the cross, so that one-half of the ore is received in them while the other half falls on to a plate on the ground. At each operation the size of the fragments is reduced by grinding, so that finally a weight of only a few pounds remains. These are ground in a cast-iron mortar under a ball to a fine powder, and from it the three samples for assay are taken. At Kroehnke's Amalgamation Works at Antofagasta, the assays of ore sampled by this method over a period of two years, the lumps being broken to the size of a walnut, when compared with those made on the ore prepared for reduction, *i.e.* ground to a fine powder under edge runners, showed a difference of between 0·5 and 2 per cent. on the silver contents of ores ranging from 80 to above 300 ounces per ton, being sometimes above and sometimes below.

Analysis of Silver in the Moist Way.—M. A. Guyard, in the *Bulletin de la Société Chimique de Paris*, says there exists in the territories of Utah and around the Great Salt Lake enormous deposits of spongy silica, evidently deposited from hot water. These silicas are coloured, very variously, by oxide of lead, oxide of copper, and oxides of iron—hydrated and anhydrous. Nearly all are impregnated with oxide of lead and chloride of silver. Their proportion of silver varies from 1 to 10 kilos. per ton. The great quantity of silica which these ores contain (rarely less than 90 per cent.) render them very difficult to treat; hence the ores of the Salt Lake are the despair of smelters. Those of Utah are not rich enough to bear the cost of carriage, and must be utilised upon the spot, where salt-pyrites, manganese, oxides of iron, charcoal, and wood are plenty. The real difficulty lies in the fact that the chloride of silver of these ores is scarcely soluble in alkaline chlorides and hyposulphides, whilst roasting the ores, either at high or low temperatures, renders them still less soluble.

A mixture of Utah ore ground, 1 part, and of oxide of manganese 1 part, common salt 3½ parts, and strong muriatic acid 7 parts, is heated to the boiling temperature and maintained at it until all the chlorine has escaped. The liquor is then decanted, and the residue washed once or twice with hot water. Almost all the chloride of silver will be found in the solution, whence it is separated by precipitation with metallic iron.

Along with the silver, lead, a little copper, and other minerals are deposited, forming a metallic paste, from which fine silver is extracted by cupellation. The following method of operating is recommended:—The ore and the salt are first mixed, half of the muriatic acid is added, and the mass is boiled. By this the oxide of lead is dissolved, and the chloride of silver is laid bare. The second half of the muriatic acid is then added, and the manganese is gradually introduced (about one-tenth at a time), permitting all the chlorine to escape before adding a fresh dose.

The residual burnt pyrites always contain gold. The vessels for the treatment of the silver ore should be of wood, slightly charred on the inside, the contents being boiled by a jet of steam.

New Zealand Silver.—A mass of native silver was sent from the Thames goldfield, New Zealand, to Mr. Pattison Muir, and shown to the Manchester Philosophical Society. The analysis was:—

Silica and gangue	1·93
Silver	97·05
Mercury	0·28
	99·26
Copper	0·00005
Iron	0·00100
Bismuth	minute traces

Silver, Assay of.—The following note from the *American Chemist* on the cause of discrepancies in the estimation of silver in pig lead, by Dr. Paul Schweitzer, is interesting:—'He had occasion, he says, some years since, to determine the silver in a lot of lead from one of the Western States, and took two samples for this purpose

from a kettle which contained about 10 tons of melted metal. The mean of the two assays indicated 81·62 ozs. of silver, inclusive of 0·36 oz. of gold, to the ton of lead, while other parties who assayed it at the same time, but took their samples from one or more slabs cut out of the middle of the pigs, reported less. Thinking it not at all unlikely that there might be a difference in the composition of the metal derived from different parts of the pig, Dr. SCHWARTASS cupelled seventeen samples, each weighing about 16 grams, and taken from a pig of about 85 lb. in weight, under nearly uniform conditions, and he found that the silver collects in larger quantity on the outside than in the interior of the pig, in greater proportion on the upper than on the lower side, and in fact more in all those parts which solidify first.'

Production of Silver in California in 1876.—'The silver yield of Nevada has been larger this year than ever before. The Consolidated Virginia has continued to pay its monthly dividend of $1,080,000, commenced in February, 1875, and in May, 1876, its companion mine, the California, began to reward its stockholders at the same liberal rate; the two now yield $25,000,000 net, and $37,000,000 gross a year, and most of the former sum goes directly into the pockets of the San Francisco stockholders. It is asserted by persons supposed to have good sources of information, that a large body of very rich ore has of late been found in the lower levels of the Consolidated Virginia, and that it extends into the adjacent Best and Belcher mine. If this be true, this bonanza will, at no distant time, pay dividends to three companies at least, possibly to more. The opening of a large body of ore in the Justice indicates the situation of the lode south of the Overman, a point about which there was previously much doubt; and other discoveries, whispered about in confidence, if correct, will show that the rich portion of the lode extends considerably beyond the Ophir on the north and the Belcher on the south, and raise the hope that other bonanzas will come into competition with the ore now worked in the limits of Virginia City. The mining districts of Nevada generally, with the exception of the Comstock Lode, are under a cloud. Eureka has probably not produced one-third as much bullion in the first ten months of 1876 as in the corresponding period of 1875. The decline in the price of silver, a strike among the miners, the exhaustion of the rich ore-bodies in some of the mines, and the increasing cost of charcoal on account of the scarcity of wood, contributed to the stoppage of work. White Pine and Pioche have not recovered from the prostration which struck them in previous years.'—The *San Francisco Alta*.

CANADA.—Nuggets and grains of native silver have been found in washing for gold in all parts of British Columbia. The following extract from a report made by the Minister of Mines is of interest:

'True veins of silver ore were discovered about 1871 in the Cascade Mountain Range at Fort Hope, about 80 miles from the mouth of Fraser River and 6 miles south of the town. The first lead, called the Eureka Mine, crops out about 5,000 feet above the river level, is well defined, 4 to 7 feet in thickness, and has been traced 3,000 feet. A tunnel has been driven into this lead 190 feet. The ore is described as argentiferous grey copper, and has yielded, under assay, from $20 to $1,050 worth of silver to the ton.

'During the time the above lead was being worked, another about 300 feet distant was discovered. This is of a far more valuable character, and is called the Van Bremer mine. The ore is described as chloride of silver, and has yielded, under assay, from $25 to $2,408 of silver per ton of rock. A quantity from the outcrop sold at Francisco at $420 a ton. The lead is distinctly traceable for half a mile.

'A specimen of the Hope silver ore—"a yellowish decomposed veinstone"—assayed by Dr. HARRINGTON, gave 271·48 ozs. to the ton of 2,000 lb.; it also contained lead, copper, antimony, iron, arsenic, and sulphur.

'A specimen from the Eureka mine—"a veinstone of spathic iron with some quartz"—assayed by Dr. HUNT, gave 347·08 ozs. of silver to the ton of 2,000 lb., also sulphur, antimony, and copper.'

Silver ores are found at Jarvis Island, on the north-west shore of Lake Superior, at Pointe-aux-Mines, and McKellar's Island, Thunder Bay, Silver Islet, and other parts in Lake Superior; also in Oregon and other parts.

NEW SOUTH WALES.—Silver glance, sulphide of silver = Ag^2S. This ore has been found with iron pyrites in quartz, also in limestone on the Clarence River, and on the Manning River; at two or three places near Bathurst, at Copper Hill on the western side, and at Brownlee; on the Page and Isis Rivers; at Brunaby Creek, county Argyle; at Broulee, Moruya, with cobalt, zinc, and iron; Teesdale, county Bathurst; Queanbeyan River, Burra Creek, Yass River; Buckinbath; Tacking Point, county Macquarie; Borrowa Creek; Crookwell River; with gold, lead, and zinc at Gulgong; with carbonate of lead at Peelwood; with galena and iron pyrites at Shellmalleer; on the Molonglo River, near junction with the Murrumbidgee, and at junction of

Murrumbidgee Creek with Mountain Creek. In nearly all cases the sulphide of silver occurs mixed more or less intimately with galena, so that properly it should usually be termed argentiferous galena.

The Produce of the Colony of New South Wales.—The compiler of the *Mines and Mineral Statistics* of New South Wales assures us that there are no reliable returns before 1869:—

Year	Quantity		Value
	Ozs.	dwts.	£
1869	753	0	199
1870	13,868	0	3,601
1871	71,311	18	18,681
1872	49,544	17	12,663
1873	66,997	10	16,273
1874	78,027	0	18,850

307 tons ore + 291,238 ozs. 11 dwts. silver, £77,210.

United Kingdom.—It will be understood that, with the exception of a small quantity of silver found native at Wheal Newton, in Cornwall, and a little separated in the treatment of iron pyrites from British mines, all the silver is obtained from lead ore. It will be observed that the lead ores of different counties vary very much in the quantity of lead contained in them; the lead ores of Devonshire and of Cornwall being the richest, those of Derbyshire and Shropshire being the least argentiferous. Much of the Shropshire lead is, indeed, entirely free of silver, and this ore is sold at an advanced price to the potters as 'potters' ore,' the presence of silver giving a little colour to the glaze in which the lead is used. At p. 817, vol. iii. will be found the production of silver up to 1873, the following table continuing from that date:—

Counties	1874	1875	1876
England.	Ozs.	Ozs.	Ozs.
Cornwall	35,904	25,051	37,650
Devonshire	7,809	4,642	5,590
Somersetshire	400	—	—
Derbyshire	800	—	—
Shropshire	1,912	4,384	2,745
Cumberland	10,395	12,028	10,600
Yorkshire	1,600	7,435	8,850
Westmoreland	13,704	10,114	5,214
Durham and Northumberland	70,836	70,161	74,095
Wales.			
Brecknockshire	30	—	139
Cardiganshire	41,047	46,624	45,418
Carmarthenshire	1,651	1,327	1,010
Radnorshire	150	—	66
Pembrokeshire	585	669	—
Montgomeryshire	55,081	64,981	67,414
Merionethshire	684	696	222
Denbighshire	12,100	10,873	13,246
Flintshire	22,351	12,000	13,151
Carnarvonshire	4,042	4,750	4,659
Isle of Man	161,612	163,024	170,196
Ireland	6,555	6,935	6,510
Scotland	11,317	13,303	12,214
Total	509,277	457,358	485,402

Value of ore imported into the United Kingdom; or ore, of which the greater part in value was silver:—

Countries	1874	1875	1876
	£	£	£
From Germany . . .	—	—	36,284
„ France . . .	—	—	12,860
„ Spain	205,079	249,100	292,341
„ United States of America	47,159	8,660	5,287
„ Mexico	2,254	7,919	14,572
„ New Granada . .	8,216	28,035	10,503
„ Peru	175,920	35,753	55,774
„ Bolivia	103,806	117,745	21,713
„ Chili	225,986	77,145	42,015
„ other Countries . .	5,998	20,796	8,406
Total . . .	769,355	545,164	499,775

Silver Bullion *coined at the Mint in* 1874.—The *Miscellaneous Statistics* gives no information later than 1874. In that year there were coined:

		Value £	s.	d.
Silver crowns . .	993,600·000	273,240	0	0
Half-crowns . . .	675,360·000	180,774	0	0
Florins	1,000,080·000	275,022	0	0
Shillings . . .	384,480·000	105,732	0	0
Groats	—	—		
Threepenny pieces .	202,320·000	55,636	0	0
Twopenny „ . .	—	—		
Three-halfpenny pieces .	—	—		
Maundy money . .	720·000	198	0	0
Total . .	3,256,560·000	890,604	0	0

United States.—The production of silver in the United States is given by Dr. Rossiter W. Raymond as follows:—

From 1848 to 1858, inclusive, $50,000 per annum .	$550,000
1859	100,000
1860	150,000
1861	2,000,000
1862	4,500,000
1863	8,500,000
1864	11,000,000
1865	11,250,000
1866	10,000,000
1867	13,500,000
1868	12,000,000
1869	12,000,000
1870	16,000,000
1871	22,000,000
1872	25,750,000
1873	36,500,000
Total	$186,800,000

Transactions of the American Institute of Mining Engineers, 1875.

The production of silver in the states and territories west of Missouri River during 1876 was $42,000,000 silver ore, and obtained from lead $5,000,000.

The conditions under which silver occurs in nature are described in the article already referred to, and the districts in which the various ores are found are distinguished. The development of the mines in North America will, however, require some additional notice. Quoting in the former article from Mr. John Arthur Phillips's work on 'Gold and Silver,' a table was given showing that the production of silver in the world in 1865 was equal to about 4,000,000 lb., of the value of 12,000,000*l.* sterling.

This was increased in 1875, as shown by the following table compiled for the French Government, to the value of more than 15,000,000*l.*

The Production of Silver throughout the Globe since 1852, *extracted from the* Journal Officiel *de la République Française du* 16 *Juin*, 1876:—

1852	202 millions of francs.
1853	203 "
1854	202 "
1855	203 "
1856	202 "
1857	203 "
1858	202 "
1859	203 "
1860	202 "
1861	213 "
1862	225 "
1863	245 "
1864	257 "
1865	260 "
1866	253 "
1867	270 "
1868	250 "
1869	237 "
1870	258 "
1871	303 "
1872	323 "
1873	350 "
1874	357 "
1875	403 "
	6,030 millions of francs

= about 226,125,000*l.* sterling.

The production of silver in the world in 1875 having been valued at 15,125,500*l.* sterling.

The depreciation of the value of silver has during the past year (1875) been the cause of much alarm in the commercial world, this alarm being, to a great extent, needless.

The average price of silver for the past five years has been as follows:—

	s.	*d.*	
1872	5	$0\frac{1}{4}$	
1873	4	$11\frac{1}{4}$	
1874	4	$10\frac{5}{16}$	
1875	4	$8\frac{7}{8}$	
1876	4	$4\frac{1}{2}$	in the first eight months.

We learn, especially from the report of Mr. Goschen's committee on the depreciation of silver, that this reduction in the value of this metal was principally, if not entirely, due to the enormous production of silver ores from the mines of the United States of America; the words of the report being that the depreciation in the value of silver was due to the discovery of new silver mines of great richness in the state of Nevada. The estimate for the year 1876, says an able writer in the *Times* of November 24, 1876, well acquainted with the subject is exceedingly wide of the mark. Nothing could show more conclusively how untrustworthy the statistics of Government officials frequently are, and how mischievous their miscalculations may be than the present case. Dr. Linderman, the Director of the United States Mint, estimated the production of silver in the United States for 1876 at \$50,000,000, or 10,312,500*l.* sterling; whereas the best authorities in California, with the figures to the end of September before them, estimate the amount for the year at \$26,000,000, or about 5,291,666*l.* sterling. It was stated in the *Times* of August 29 that the year's production would be between \$25,000,000 and \$30,000,000. The total yield will be about 24,000,000 ozs. of fine silver, this being the most accurate form of estimating, as the price during the year has been subject to considerable fluctuations. The loose manner in which in nearly all the statistics of silver here the *doré* bullion—that is, gold and silver in combination—has been classed as silver, has been the chief cause of erroneous calculations, and now the principal mines are beginning to report the exact amount of silver as distinguished from gold. The fact that the large amounts said to have been

produced have not appeared on any of the silver markets of the world, is most conclusive evidence as to over-estimate.

So that, taking the estimates of the production of silver from the returns of the mines, and from those engaged in the purchase and shipment of silver, the year's production in the United States may be set down at about $28,000,000. (The 24,000,000 ozs. of silver at 4s. 4½d. the ounce gives a value of 5,250,000*l.*) There is not the slightest doubt that the silver product of the United States has all along been exaggerated, and those who have access to the best sources of information consider 24,000,000 ozs. of fine silver a full estimate, and one, moreover, that, with the amplest knowledge of the prospects of further production, they think is not likely to be exceeded in future from the present known sources. There is, therefore, nothing to warrant expectations of enormous production, and the discovery of new mines of great value is entirely speculative, there being always some slender chance of such a thing, though no more now than at any time in the last twenty-five years. It is evident also that if the present supply is to be kept up for an indefinite period new mines must be discovered to take the place of those now being worked out. Humboldt, in his great work on Mexico, has shown that nearly one-half of the whole gold and silver production of Mexico came from three mining districts, while the remaining half came from about fifty districts, comprising about 3,000 mines. So it is in Nevada—the great production has been from the Comstock Lode; all else in that state and the surrounding states has been comparatively insignificant.

At the same time (the writer already quoted continues) there may be additional production from two sources. The Sutro Tunnel, on which about 500,000*l.* has been expended, and the total length of which will be 20,178 feet from the mouth of the tunnel, near the Carson River, to the Comstock Lode. The works were distant, December 1877, 1,830 feet, and since that time they have regularly advanced 80 feet a week; and as it runs at right angles to all the lodes of which the Comstock is the chief, it may strike some new lodges of value before reaching the Comstock, or after passing through it into Mount Davidson. The great object of this tunnel is to cut the Comstock at a depth of about 1,800 feet, so that the enormous bodies of water that now have to be pumped from that, and even from lower depths, with powerful and very costly machinery, may run off through the tunnel into the Carson River, and may, at the mouth of the tunnel, give ample water for the mills intended to be erected there for the reduction of the ores which it is expected will be run out through the tunnel. It will not reach the Comstock for at least fifteen months yet, but when completed it will be of immense service to the mining interest. Yet, with all its advantages, with the prospect of cutting unknown or undeveloped ledges, and of enabling low grade ores to be worked at a profit that cannot be reduced to advantage at present high cost of mining and milling, the superintendent of the Sutro Tunnel Company makes an estimate of the production of the Comstock at $30,000,000 of silver and gold on an average for the next ten years, the division probably being 55 per cent. of silver and 45 per cent. of gold. One of the most trustworthy papers—the *Evening Bulletin*—in summing up lately the proportions of silver and gold in the leading Comstock mines, comes to the conclusion that on an average there is 52½ per cent. of silver and 47½ of gold.

The other probable source of increased production is Arizona, which before long will be placed in communication with this city (San Francisco) by the Southern Pacific Railway, of which 600 miles of the 715 from this city to the Colorado River, at Fort Yuma, are completed. The railway, when extended through Arizona, will open up new mining fields at present too inaccessible to be worked to advantage. Yet, while the states or territories of Nevada, Oregon, Utah, Montana, Idaho, Colorado, and Arizona itself have abundance of mineral belts that have been largely explored, there has not been found more than one exceptionally large silver lode—the Comstock—and it is probable that the railway, even if completed through Arizona, might not materially increase the production of silver.

The movements of silver in the United States must come into our calculations. The exports from all ports for the years ended June 30, less the imports, amounted in 1872 to $25,302,543; in 1873, to $26,053,360; in 1874, to $23,636,216; in 1875, to $17,947,241. The exports, less imports, of gold and silver (not silver only) at the port of New York for the period from January 1 to September 30 of the following years:—$55,102,000 in 1872; $30,453,000 in 1873; $38,489,000 in 1874; $53,900,000 in 1875; and $33,434,000 in 1876. The exports, less imports, of silver at the port of San Francisco from January 1 to September 30, 1875, were $1,924,632; and for the same period of 1876, $3,943,843.

The silver question in the United States may, therefore, be summed up in few words. The total production for the year 1876 will amount to about 24,000,000 ozs.

of fine silver, valued at \$1 15c. per ounce at \$27,000,000 in gold, and there is no reasonable expectation of increase for the future from all known sources, while the continuance of the present supply is, to say the least, problematical. The redemption of the fractional currency will require \$20,000,000 more, and if coinage is commenced for resumption on January 1, 1879, on the single gold standard, there will be needed at least \$75,000,000 of subsidiary silver coin; and if the double standard be adopted, involving full-valued silver coin, or the single silver standard be adopted with gold as subsidiary, it is difficult to say to what price silver may rise.

The total imports into the United Kingdom for the eight months ended August 31, 1876, were 8,286,707*l.*, against total exports during the same period 7,559,314*l.*, showing the net imports to be 727,453*l.* Now, taking the allowance for eight months for manufacturing purposes of 400,000*l.*, the report of Mr. Goschen's committee setting down the annual consumption at 600,000*l.*, and estimating the coinage for the same period at 400,000*l.* in the proportion for the year 1875, these two items give 800,000*l.* against a net import of 727,453*l.* On further analysing the tables of export and import—in the supplement to the *Economist* of September 9, 1876—the imports of silver from Germany during the first eight months of 1876 were 2,669,271*l.*, against 707,375*l.* in the same period of 1875, showing the imports to be 1,961,896*l.* more in the period of 1876 than of 1875, and, allowing for an excess of export to Germany for the period in 1876 as compared with 1875, the net imports from Germany into the United Kingdom were 1,898,383*l.* more in the first eight months of 1876 than of 1875. On the other hand, the diminution of net imports from Mexico, South America (except Brazil), and West Indies amounted to 511,219*l.* for the period of 1876 as compared with 1875, and similarly a diminution in net imports from the United States of 81,912*l.* So that, looking on the supply and demand as almost exactly balanced in the period under consideration, the supply is only kept up by an excessive import of 1,898,383*l.* from Germany, a merely temporary source of supply, whereas the United States, Mexico, South America, and the West Indies, the permanent sources of supply, from which largely increased quantities were confidently reckoned upon, show a falling off during the eight months of 593,131*l.* Further, the total imports of silver into the United Kingdom for the four years and eight months from 1872 till August 31, 1876, were 54,836,000*l.*, and the total exports for same period were 49,093,000*l.*, making net imports 5,743,000*l.* Taking the figures for coinage for the four years—namely, 3,610,115*l.*, and taking 400,000*l.* for the eight months in 1876 as already estimated, and adding for manufacturing purposes 600,000*l.* per annum—a total home consumption for these four years and eight months is obtained of 7,210,000*l.*, against a total net import during the same period of 5,743,000*l.*, making an excess of export and consumption of 1,467,000*l.* over the supply. Moreover, the net exports of silver to British India for the first eight months of 1876 exceeded those during the same period of 1875 by 1,022,020*l.*, and if British India, China, and Japan are taken together, the increase of export was 1,360,325*l.*

The average price of silver during these last five years of deficient supply fell from 60$\frac{5}{16}$*d.* in 1872 to 59$\frac{1}{4}$*d.* in 1873; to 58$\frac{5}{16}$*d.* in 1874, to 56$\frac{7}{8}$*d.* in 1875, and to 52$\frac{3}{4}$*d.* in the first eight months of 1876. The average price from 1852 to 1872 had been 61*d.*, and from 1868 to 1872, 60$\frac{1}{2}$*d.* The fall from 52$\frac{3}{4}$*d.* to 47*d.* in July last may be regarded as the depreciation of sheer panic; but the actual fall from 60$\frac{5}{16}$*d.* in 1872 to 52$\frac{3}{4}$*d.* is 13$\frac{1}{2}$ per cent., and from 56$\frac{7}{8}$*d.* in August, 1875, to 52$\frac{3}{4}$*d.* in August, 1876, about 7$\frac{1}{2}$ per cent. We may remark here that the rise of the price of silver, after the gold discoveries in Australia and California, was from 59$\frac{1}{2}$*d.* to 62*d.*, or only 4$\frac{1}{2}$ per cent.

The supply of silver thus falling short of the demand, the actual fall in price must arise from one of two causes. Either the cost of producing or acquiring it has diminished, or the cost of producing gold or of acquiring it has increased. There is no reason for supposing that the cost of producing silver has diminished, as although two mines in Nevada are making extraordinary profits at present, this is not the case in Mexico, South America, or in many other mines in Nevada; and, following the economic law that the price of the total production of any article is determined by the cost of that part of the supply which is produced at a profit under the greatest disadvantages, it is clear that the price of silver will not be determined by the cost in the more profitable mines of Nevada, but by the cost in the least profitable mines of Nevada, Mexico, and South America.

The *Gold Hill News* informs us that the *Alta* and the neighbouring mines are developing remarkably well, that the *Trojan* mine is turning out 50 tons of ore per day, worth from \$30 to \$40 per ton. The Ophir Gold and Silver Mining Company state that 'the best experts on the lode are more confirmed than ever in the belief that the drift on the 1,900 level will lead to a large and valuable ore deposit. The Ontario Silver Mining Company produced between November 1 and 22 bullion to the value

of $121,760·38 assay value. The EUREKA CONSOLIDATED MINES produced in November silver ore of the value of $353,645, and other mines were equally productive. These facts are important in relation to the foregoing remarks.

Fluctuations in the Price of Bar Silver per Ounce from 1833 to 1876, compiled from PIXLEY *and* ABELL'*s Tables* :—

Years	Yearly Average Price	Silver coined in England	Export of Silver to the East	Importation in Bars and Coin	Remarks
	d.	£	£	Ozs.	
1833	59$\frac{3}{16}$	145	1,305,023	—	
1834	59$\frac{15}{16}$	432,775	2,146,465	—	
1835	59$\frac{11}{16}$	146,065	2,036,167	—	
1836	60	497,710	2,610,101	—	
1837	59$\frac{9}{16}$	76,385	3,010,100	—	
1838	59$\frac{1}{2}$	174,042	1,945,264	—	Famine in India. Affghan War.
1839	60$\frac{3}{8}$	390,654	1,786,253	—	
1840	60$\frac{3}{8}$	297,900	1,841,335	—	
1841	60$\frac{1}{16}$	89,641	3,143,292	—	Great depression in manufactures.
1842	59$\frac{7}{16}$	102,852	4,704,675		Peace with China. Income tax passed.
1843	59$\frac{3}{16}$	239,590	3,752,472	—	Treaty of Commerce with China.
1844	59$\frac{1}{2}$	610,632	2,495,050	—	Bank Charter Act passed.
1845	59$\frac{1}{4}$	647,658	2,930,922	—	Railway mania. Sikh War.
1846	59$\frac{5}{16}$	559,548	1,973,894	—	Commercial panic. Repeal of Corn Laws.
1847	59$\frac{11}{16}$	125,730	4,204,503	—	
1848	59$\frac{1}{2}$	35,442	3,596,907	—	
1849[1]	59$\frac{3}{4}$	119,592	3,811,600	—	First importation of Californian gold.
1867	60$\frac{9}{16}$	193,842	642,912	8,020,000	Great decline in export.
1868	60$\frac{1}{2}$	301,860	1,635,642	7,716,420	Abyssinian Expedition.
1869	60$\frac{7}{16}$	76,428	2,062,943	6,730,000	Distress in Lancashire.
1870	60$\frac{9}{16}$	336,798	1,579,473	10,649,000	Franco-Prussian War.
1871	60$\frac{1}{2}$	701,514	3,712,473	16,520,000	Peace between France and Germany.
1872	60$\frac{5}{16}$	1,243,836	5,654,461	11,140,500	Commencement of decline in price of silver.
1873	59$\frac{1}{4}$	1,081,674	2,497,576	12,302,200	Demonetisation of silver in Germany.
1874	58$\frac{5}{16}$	890,604	7,092,720	11,707,000	20,000,000*l.* gold in Bank of France.
1875	56$\frac{7}{8}$	594,001	3,714,404	9,506,757	Heavy failures.
1876	52$\frac{3}{4}$	222,354	10,914,407	13,685,608	The lowest price on record.[2]
1877	54$\frac{13}{16}$	420,046	17,007,530	21,015,652	Great famine in India. Russo-Turkish War.

SISKIN YELLOW. A greenish yellow dye, so called from its resembling the colour of the yellow or greenish yellow wing feathers of some varieties of the finches (*Fringillinæ*) or siskins, amongst which are the common greenfinch or green linnet, and the canary bird (*Carduelis canaria*.)

[1] From this date the price of bar silver per ounce steadily fluctuated a trifle up or down of 60d. until 1867.

[2] The prices through the months of the year 1876 :—

	d.	d.
January	54$\frac{3}{4}$	53$\frac{3}{4}$
February	53	52$\frac{1}{2}$
March	55$\frac{1}{4}$	54$\frac{1}{2}$
April	54$\frac{1}{4}$	54
May	52	54
June	50	50
July	46$\frac{3}{4}$	51$\frac{1}{2}$
August	50$\frac{1}{2}$	53$\frac{1}{2}$
September	51$\frac{1}{2}$	53$\frac{1}{4}$
October	52	53$\frac{1}{4}$
November	53$\frac{1}{4}$	55
December	56$\frac{1}{4}$	56$\frac{1}{4}$

SKINS. The importation of skins of various kinds into the United Kingdom in 1876 was as follows:—

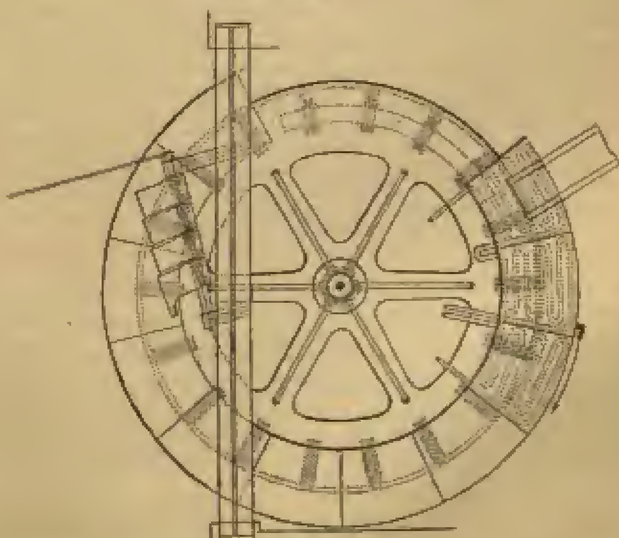
	Number	Value £
Goat and kid (undressed)	1,318,366	168,077
" " (tanned, tawed or dressed)	6,732,720	706,602
Seal	607,276	219,640
Sheep and lamb (undressed)	7,598,967	980,115
" " (tanned, tawed or dressed)	5,586,381	353,924
Furs (unenumerated)	7,674,936	835,305
Skins, not furs (unenumerated)	1,589,640	244,390
Skins, furs (articles manufactured)	—	191,820
Natural history specimens	—	16,074

SLAG COTTON. See Slag Wool.

SLAG, UTILISATION OF. (Vol. iii. p. 839.) In the former article the early experiments made by Mr. Charles Wood, of Middlesborough, are mentioned. Since that time the processes have been more fully developed. That gentleman, in a paper read before the Iron and Steel Institute, especially describes his slag cooling machine and that for making slag sand. After noticing the experiments made in this direction by Mr. Bessemer, he proceeds to mention the efforts made to utilise the slag from iron furnaces made by Messrs. Smeeton and Bowler, Messrs. Boomer and Wilson, Mr. John Gjers, Mr. Lürmann, Mr. Thomas Bell, and Mr. D. Joy. All these are credited with doing good service, but nothing of any practical advantage has resulted from their experiments. Mr. H. Wood then proceeds:—

'The whole question became one of serious moment, and many minds being directed to the same point, numberless schemes were proposed. Mr. David Joy patented several forms of wheels, upon which he fixed cast-iron trays or troughs, or more properly speaking chills for the cooling and disintegration of slag, and my own patent

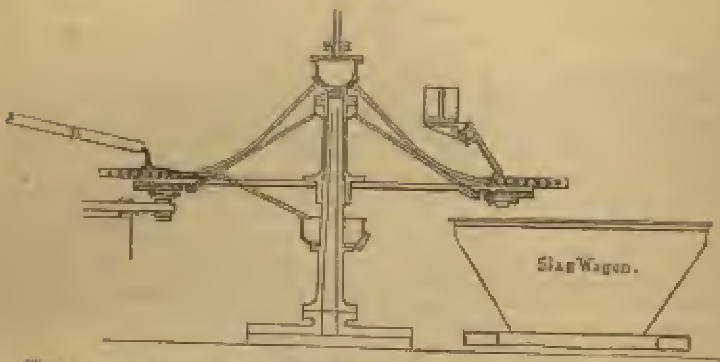
2528



for a horizontal disintegrator was perfected and set to work. The sand cooling machines are shown, *figs.* 2528, 2529. But the matter did not rest here: the more I went into the question the more evident it became that by disintegration slag could be made of much value. Experiments proved this, and the vertical granulator or sand-making machine, somewhat resembling one of the forms included in Mr. Joy's specification, but divested of the chills or troughs, and having the sides partially closed in, very similar to the rotatory puddler shown in end section by Dr. Siemens, is the latest, and I by no means say the last result. And it is to draw your attention in the simplest and briefest manner to the products of these two machines and their uses that I venture to make these few remarks.

'My first machine receives the slag on a horizontal rotative table, as shown in drawing (*fig.* 2530). This table is composed of thick slabs of iron. These slabs are kept cool by a circulation of water through them. The machine revolves very slowly. The liquid slag flows upon the table and forms its own thickness, varying from ¼ inch to ¾ inch. As soon as the slag has parted with sufficient heat so as to become solid, water is allowed to run freely upon the surface, and by the time it arrives at the scrapers, it is sufficiently cool to part from the table freely and break up, and then drops into the waggons.

2529

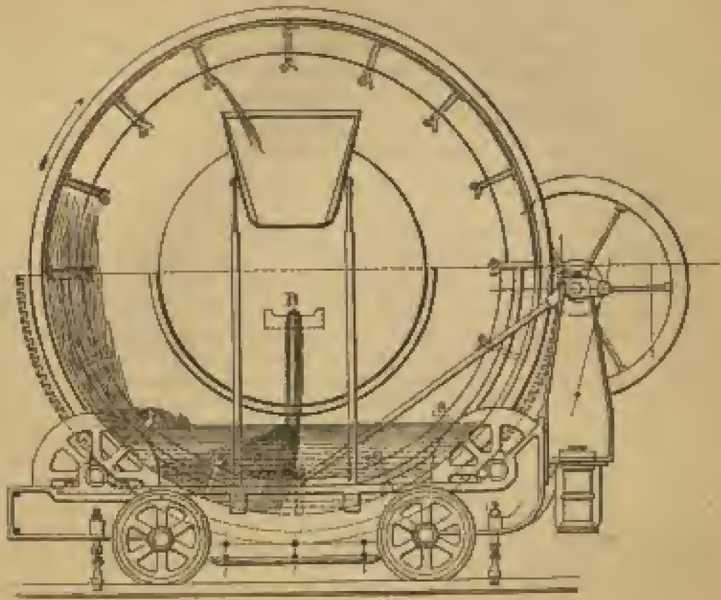


'This process, which is in successful operation, is that known as WOODWARD'S, and, although a revival of a very old method, I must certainly give that gentleman, and those who have worked the thing out at the furnaces, a great deal of credit for their perseverance and for the success at which they have arrived. I must also, in all honesty to them, say that most of their manufactured articles are of a very serviceable nature. They are, however, only employed for footpaths, roads, &c., being totally unfit for building purposes. As at present worked, the process is not at all complicated, but only certain qualities of slag are suitable, and at times, when the furnaces are "changing," the number of wasters is enormous, while the works have sometimes to be stopped for days. The slag is run direct from the furnaces into moulds ranged round the outside of a large rotary table. The machine or table remains stationary whilst each separate mould is being filled; the table is moved by hand, thus constantly presenting empty moulds to the stream of molten slag. As soon as the slag becomes set in the moulds a catch is knocked away, and the bottom of the mould drops down upon a hinge and the brick or block falls out. It is then taken into annealing ovens, where the temperature is raised to nearly a white heat, after which it is allowed to cool. The high price obtained in the market for these goods enables the company to meet their expenses, but, I believe, up to the present time they have not done more than this. The goods they produce are very hard, uniform in size, and look well when laid; but they are liable to crack, particularly in winter.

'The slag sand machine is just the opposite in principle to the first-named machine, and is shown in drawing (*figs.* 2531, 2532). As the whole body of liquid slag runs from the furnace it flows directly into a deep bath of water. This water is kept in a violent state of agitation, and the liquid slag is instantly scattered in the body of water in the shape of sand, the water taking up the heat and throwing it off again in the shape of steam.

'The action of the slag-sand machine will be better understood by consulting the drawing (*fig.* 2530). It will be seen that it is made in a shape not unlike a rotatory puddler, only having sides, to enable it to contain from 2 feet 6 inches to 3 feet of water in the bottom. This cylinder is kept in motion by a small steam engine. The water is agitated by means of a certain number of buckets placed in the inside of the periphery. These buckets are perforated, so as to act as screens, to separate the sand from the water; they also elevate the sand to the top of the machine, where it drops into a spout, and thence into waggons. The speed of the machine is about 100 feet per minute, or about four and a half or five revolutions, according to the nature of the slag. Thus the water is always in a state of rushing towards the bottom, and, meeting with the screens or floats, it rolls over in a violent manner. Into this water the slag is allowed to run direct from the furnace. The water acts upon the stream of slag by scattering it, as it were, and the action is so perfect that no crust, or any

2530



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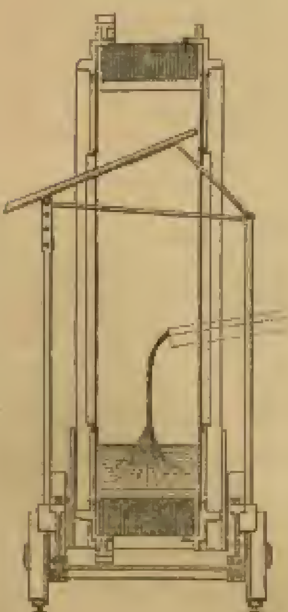

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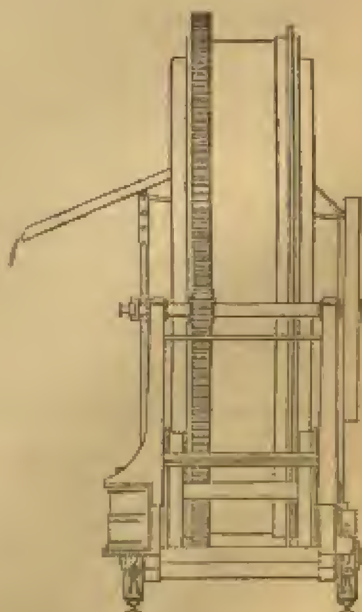


pieces larger than those shown, is allowed to form. The action of the machine is perfect, delivering the slag in a constant stream into wooden railway trucks, fit to be sent or dealt with in any way.

'We now come to consider the way in which we can best utilise this slag sand. Mr. Bosmer, in a paper read before your Institute last year, stated that, by mixing eight parts of granulated slag with one of cement, he could produce a valuable brick. By his process the sand requires no further manipulation than the mixing with lime and compressing in a hydraulic press, when, after two or three weeks' exposure to the air, they are fit for use. The advantages and economy of this material are manifest, and these must, from their great cheapness, displace millions of bricks made on the old plan of burning.

'We now come to consider the use of this material, as a substitute for sand, for building purposes.

'Mortar, made from this sand, mixed in the proportion of one part lime to five parts of sand, when ground up together, is said to be nearly equal to cement. If a small portion of ironstone be added, equal to about 5 per cent., this material increases its strength. It is thought this sand, produced, as it can be, at the same, or little more, than the present cost of running into balls, will produce a material which will be very valuable to farmers, containing, as it does, from 30 to 35 per cent. of lime, 36 per cent. of silica, and 3 per cent. of sulphide of calcium. Its light and porous nature, in opening and lightening up the land, will also be of great service.

'Concrete blocks, made with a combination of my first patent slag, and the second, or slag sand, are suitable for foundations of all descriptions, and even for walling for cottages. This material is composed of six parts of machine slag, and one part of the mortar, composed of five parts of slag, with one part of lime, well ground up. These have all been mixed together and formed into a block.

'I have only one more remark to make before concluding. I think I have proved beyond a doubt that slag can be utilised, and that it can be put into the market at a very low price compared with other materials, and that it contains very valuable chemical combinations, different from any other. With these facts before me I do not see why hundreds of thousands of tons each year should not be made use of; and that, as this, mostly, must be put into railway trucks for transport, it may become as much a source of revenue to railways as the carrying of pig iron, or other produce, and thus again be made to produce a useful effect.'

Cost of making Slag Sand.

Make of furnace, about	25 tons iron.
Do. do.	36 tons slag.

	Per Shift s.	d.
One man, per day	4	0
8,000 gallons (water), at 3d.	2	0
Wear of machine	3	0
	9	0 × 12 ÷ 36 = 3d. per ton

Concrete Blocks, per Cubic Foot.

		s.	d.
Rough machine slag,	8 tons	4	0
Slag mortar	1 "	4	0
	9 tons	= 8	0
Labour, 1s. per ton		9	0
		17	0 ÷ 9 = 1s. 11d.

1s. 11d. per ton, or ¾d. per cubic foot. If with ironstone, about 1d. per cubic foot.

Mortar from Slag Sand.

			s.	d.
5 tons sand, at 3d.	1	3		
1 ton lime, at 15s.	15	0		
6	16	3 ÷ 6 =	2	8
Grinding			1	4
			4	0

Four shillings per ton.

Bricks per Thousand.

	s.	d.
2 tons 10 cwt., at 3d. per ton	0	7½
Lime	4	0
Wear of machine	1	3
Coals and water	1	0
Labour, &c.	3	2
Per 1,000	10	0½

Analysis of Furnace Slag.

Silica	38·25
Alumina	22·19
Lime	31·56
Magnesia	4·14
Protoxide of iron	1·09
Manganese	trace
Calcic sulphide	2·96
	100·19

In the discussion which followed the reading of Mr. Wood's paper some practical remarks were made by Mr. Snelus, of the West Cumberland Ironworks.

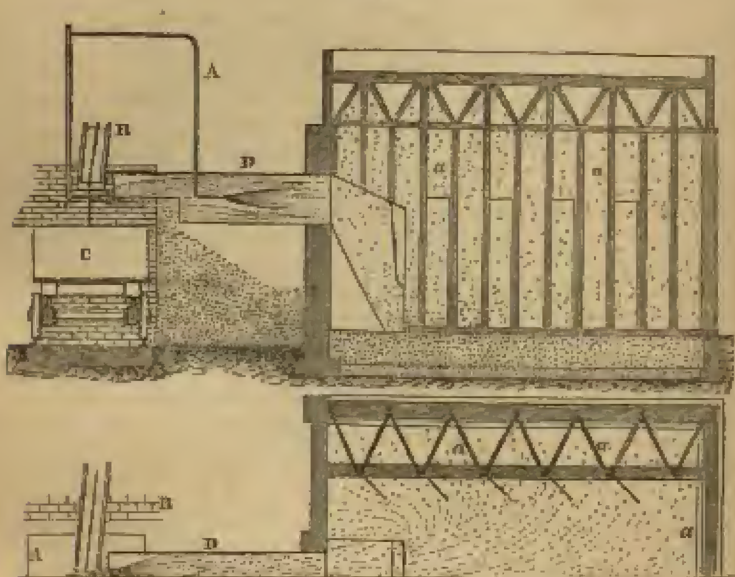
Mr. Snelus said he had given some attention to this matter, and he was now engaged in putting up a mill at the West Cumberland Works, to deal with the slag there, which, generally speaking, was highly basic, and at about this time last year (May 1876) he went to Germany, partly for the purpose of seeing Mr. Lürmann's process of utilising the slag. He had seen there slag—from a furnace working Bessemer iron, and also from white forge iron—run into water, and he found that the slag produced from the furnace working on the Bessemer pig broke up into pieces much more easily than the other, as they would expect from the large quantity of sulphide of calcium present, and Mr. Lürmann considered it a much more valuable product than that which he obtained from the black cinders when the furnaces were working on white iron. From such furnaces he considered that the slag was best utilised as ballast. Very large quantities of it were so used, but it could also be made into bricks. It required, however, a larger quantity of lime than the more basic slags, which, when mixed up with one-sixth of lime, was formed into bricks by a steam press. The bricks were dried for some weeks, and he had seen several houses built of them, which had been built some two years. He tried his pen-knife upon them, and found the bricks remarkably hard, much harder than he would have expected. He had had the pleasure of witnessing the making of bricks by Mr. Bodmer's process. Mr. Bodmer used a hydraulic press instead of a steam press. The two processes were almost identical, at all events he did not see much difference, but Mr. Bodmer had certainly a much better mixing apparatus for producing the bricks, and they were of a better and finer quality than Mr. Lürmann had yet attained. Mr. Snelus thought there was a very great future for those bricks, and that any apparatus that would enable them to get the slag into a state of sand cheaply, and with little trouble at the furnace, would be of great advantage, because that was the great thing. The great difficulty was to take the slag away from the blast furnace. They had very little room at blast furnaces to do any work, and as far as he (Mr. S.) could see, the simpler the process could be made the better, and running the slag into water seemed to him as simple a thing as they could possibly have. Running it into a deep well of water and simply moving it by a Jacob's ladder seemed to him to do all they required.

SLAG GLASS. At the Leeds meeting of the Iron and Steel Institute last year (1876), Mr. Bashley Britten introduced his novel system of making glass from blast-furnace slag. Mr. Britten proposed to take the molten slag in a ladle from the blast furnace and to pour it into a Siemens furnace, where certain additions of carbonate of soda and silica were added according to the quality of the slag used and the glass to be produced. We learn from Mr. Britten that the extensive experiments which have been carried on during the years 1876–7 have proved perfectly successful, and that under the title of 'Britten's Patent Glass Company,' for which Mr. Herbert Canning is the secretary, large works are being built at Finedon, in Northamptonshire, where in a few months they will be ready to manufacture large quantities of glass bottles.

SLAG WOOL or SILICATE COTTON. The manufacture of slag wool, or, as it is sometimes called, silicate cotton, from its great resemblance to cotton wool,

has often been attempted in England, but only with partial success. Mr. EDWARD PARRY made a large quantity of it in Wales, although, in consequence of the injurious effect upon the men, it had to be abandoned. The manufacture is now carried on at the Tees Ironworks, and Mr. WOOD says he can safely assert without the slightest inconvenience, either to the men in the yard, or even to the man who makes it. The process is extremely simple—a jet of steam is made to strike upon the stream of molten slag as it falls from the usual runner into the slag bogies or waggons. This jet scatters the molten slag into shot, and as each shot leaves the stream it carries a fine thread or tail with it; the shot, being heavy, drops into the ground, whilst the fine woolly fibre is sucked into a large tube and discharged into a chamber. This chamber is very large, and is covered with fine wire netting or sieve wire. The steam and air carry the woolly particles all over the chamber—the finest into recesses shown in the diagram (*fig.* 2583); the heavier into the body of the chamber.

2583



After each blowing it is selected and taken up with forks, and put into large casks or bags for shipment or otherwise. The inside of the chamber represents a most remarkable and curious spectacle after each blowing. The slag wool is of a snowy-white appearance, and this, hanging all about the inside of the chamber, reminds one of the old and familiar words—

Great flakes of snow,
Like fleecy wool.

Slag wool, or silicate cotton, is chiefly employed to cover steam boilers, pipes, &c. Messrs. JONES, DARE, and Co., of London, are the sole agents for its sale, and they have taken out one or two patents for its application. The most noteworthy of these is what they term mattresses, some of which they have kindly forwarded for inspection. These are about two to three feet long, and a foot wide, by two and a half inches thick. The mattresses are laid upon the boiler or pipes to be covered, and are secured in the usual way. Its perfect incombustibility, combined with its non-conducting and indestructible properties, give this material many advantages over any other for this class of work.

SLAG, BLAST-FURNACE CEMENT. The following description of this cement is given by J. J. BODMER in the *Transactions of the American Institute of Mining Engineers*:—

'Although the similarity between puzzolana, or trass, and blast-furnace slag, as seen by comparison of the analyses, is a well-known fact, blast-furnace slag has not been used commercially as a substitute for these cementing materials. The reason,

the writer apprehends, lies in the fact that unless such slag is disintegrated or subdivided by rolls, the process must either be too costly, or the material is not in a fit and proper condition for the purpose. In order to produce a reliable slag cement, the slag must be ground together with the lime into an impalpable powder. The subdivided slag must, therefore, be perfectly dry, and, at the same time, friable. The stronger the hydraulic properties of the lime, the more reliable the slag cement will be, and practice has proved that the slag from a grey-iron furnace gives the best results. The slag cement which has given the results shown in the annexed table, under pressure tests, was composed of six parts of slag, from a blast-furnace producing No. 3 foundry iron, and one part of lime, of medium hydraulic properties.

'The above-described class of cement bears storing as long as most Portland cements, and the cheapness of its production is self-evident. It is applicable in the manufacture of concrete bricks, paving blocks, roofing slates, grindstones, water-troughs, cisterns, and especially in the construction of sewers, and river and sea walls.

Comparative Analysis—Slag Cement.

	Blast-furnace Slag					Trass	Puzzolana
	Cleveland District			Wales			
Silica	36·20	40·75	34·	49·50	45·	57·12	44·60
Alumina	20·	24·47	24·35	15·20	16·43	12·60	15·
Lime	27·	24·50	34·	19·70	26·78	2·60	8·80
Gypsum	—	—	—	—	—	—	—
Magnesia	6·	7·17	5·88	3·	0·40	1·	4·70
Protoxide of iron . .	1·30	2·05	0·07	8·32	5·20	5·	12·
Potash	—	—	—	—	0·46	7·	1·40
Soda	—	—	—	—	—	1·	4·
Sulphur	0·40	0·65	1·72	1·29	—	—	—
Water	—	—	—	—	—	9·40	9·20
Protoxide of manganese .	—	—	—	—	5·64	—	—

The following are the results of some of the tests of slag cement as compared with Portland cements:—

Figures taken from Experiments made on the Strength of Portland Cements by Mr. JOHN GRANT, M.S.C.E.			Slag Cement Experiments made by J. J. BODMER. 1 part by Weight of Lime, with 7 parts of Slag.	
Weight of Cement per Bushel. Lb.	Age after Gauging	Tensile Strain sustained per 1 sq. in. Lb.	Age after Gauging	Tensile Strain per 1 sq. in.
106·7	7 days	157·6		
107·6	7 "	156·56		
111·75	7 "	201·63		
114·16	7 "	269·78	7 days	271·22
119·04	7 "	248·03		
119·07	7 "	305·60		
121·0	7 "	400·77		
—	14 "	472·26		
—	28 "	499·51	1 month	472·18
—	2 months	522·41		
—	3 "	558·62		

SMOKE, PREVENTING. The great secret of preventing smoke is to secure a careful stoker. In Cornwall this has been done, and the following system is carried out with great success. The fire under the boiler is in a state of activity, a good red surface extending to the end of the fire bars. New coal, if thrown in over this, would immediately give out a great volume of smoke, and reduce the heat of the fire; but if it be thrown in front of the fire, the black smoke which slowly escapes passes over the heated fuel and is regularly consumed, increasing thus the heat of the fire.

Nearly all the smoke-consuming arrangements are based upon the principle that fresh air must be admitted to the fireplace at that point where smoke begins to form. Then the carbon, meeting with a fresh supply of oxygen, is speedily consumed, and passes off as carbonic acid. See description of several 'Smoke Consumers,' SMOKE, vol. iii. p. 841.

SOAP. (Vol. iii. p. 843.) The following notes on the manufacture of soap are by CHARLES T. KINGZETT, and are published in his book on *The Alkali Trade*. It summarises the facts already stated in the former article in vol. iii., and gives two or three statements of interest:—

'Soaps are known as hard, soft, or silicated. Hard soaps result from the use of soda, while soft soaps are produced by using potash; of silicated soaps we shall have more to say anon.

'*Hard soaps* are manufactured from tallow, palm oil, cocoa-nut oil, resin, &c., by saponification with caustic soda.

'It will be well here to point out that the consistence of a neutral fat depends upon the predominance of olein or stearin, the first of these radicals being liquid and the second solid.

'The pans in which the saponification is effected vary in size, some being 15 ft. in diameter and 15 ft. deep, capable of yielding 25 to 30 tons of finished soap in one operation. They are constructed of wrought-iron plates, which are riveted together and heated, either by a steam pipe immersed in the contents, or by a steam jacket, or by fire. The manufacturer charges his pan with neutral fat or oil, and adds caustic lye of 1·05 specific gravity, boils and stirs. This produces a milky emulsion, to which is added fresh quantities of soda lye, each portion being stronger than the preceding one, until there is free alkali present. These processes are repeated until the pan is filled, but finally the alkali must not be in excess.

'Common salt is now added in the proportion of 10 lb. to every 100 lb. of fatty matter used, with the view of salting out (or rendering insoluble) the soap produced, which thereupon floats in granules.

'The spent lye is next drawn off and discharged, while the soapy mass is boiled with fresh weak lyes. This operation gives a homogeneous mixture, which is allowed to remain quiescent for a few hours, after which it is solidified in rectangular frames of cast-iron plates, and after four to five days, when hardened, it is cut by wires into slabs or bars.

'*Soft soaps* are made chiefly from whale, seal, and linseed oils, tallow and resin in this country, while on the Continent, hemp, linseed and poppy oils (drying oils), rape and train oils, are largely employed.

'These are saponified by potash lyes until a streaky appearance is observed, after which the product is clarified by stronger lyes, till it presents itself as a transparent slime; much of the water is evaporated off, and the boiling continued, meanwhile stirring with sticks until it "talks." It is then packed in casks as a deliquescent paste.

'*Soap from resin* is obtained both as hard and soft, according to the process employed. Resin itself is a mixture of pinic and sylvic acids, together with colophonic acid; these are highly oxidised products of turpentine, and considerable quantities are obtained as a residue in the distillation of turpentine.

'The resin is first purified and decolorised by distillation in a current of steam, after which it may be used alone, or mixed with fats. The production of soap from resin is easily explained, resin soaps being simply the alkaline salts of the acids contained in resin. These acids are capable of decomposing sodic carbonate. In short, a soap may be said to be commercially *a body which, on treatment with water, liberates alkali*. This is effected with ordinary soaps as follows:—The water decomposes the neutral sodic or potassic salt into free alkali and acid salt, which latter, being insoluble, is precipitated as "suds," while the alkali goes into solution, and, by its action upon fatty impurities, effects the cleansing which is desired. This is not at all difficult to comprehend, if it be borne in mind that soap is a polybasic salt, capable of resolution into a less basic or more acid salt, and free base.

'*Soap from Yolk of Eggs.*—RICHARDSON and WATT state that in the print-works of Alsace there are consumed annually 125,000 kilograms of dry albumen, and one kilogram requires the whites of 288 eggs. The yolks are now used for soap-making. To understand the production of soap from the yolk of eggs, we must look into its chemistry.

'Besides the olein contained in the free state, there is present a body called lecithine, of formula $C^{42}H^{84}NPO^{9}$. GOBLEY, DIAKONOW, STRECKER, THUDICHUM and KINGZETT have studied this substance, and express its chemolysis as follows:—

Lecithine		Water		Glycerophosphoric Acid		Choline		Oleic Acid		Palmitic Acid
$C^{42}H^{84}NPO^{9}$	+	$3H^{2}O$	=	$C^{3}H^{9}PO^{6}$	+	$C^{5}H^{15}NO^{2}$	+	$C^{18}H^{34}O^{2}$	+	$C^{16}H^{32}O$

That is to say, bases have the power, by abstracting water, to split up lecithine into, among other products, oleic and margaric acid. So that when eggs are used for soap-making, this process actually occurs, the soda or potash employed being sufficient to effect the necessary decomposition, and the resulting soap being therefore the product from not only the olein but from the fatty acids so formed.

'*Mottled soaps* are produced spontaneously, or by adding to the nearly finished soap crude soda liquor containing sulphide, through a watering spout. On descending through the pasty mass any iron present is seized and precipitated in veins, thus presenting in the soap the appearance of marble. Or, instead of this proceeding, a slight addition of Prussian blue is made to the soap. In France, sulphate of iron is added during the boiling, by which means ferrous oxide is first formed, and this rapidly peroxidises and gives rise to the mottled character in a great degree. Mottling is simply a trade practice, and serves no useful purpose.

'*Hard soaps*, when genuine, have the following composition:—In the case of mottled soap, 20 per cent. water; in white, equal 25 per cent.; and in yellow, 30 per cent., together with 8 to 9 per cent. alkaline bases, and 60 to 70 per cent. of fat acids. (RICHARDSON and WATT.)

'*Soft soap* is generally used for "fulling" and for cleansing and scouring woollen stuffs. It has a composition which is expressed by the following analyses given by RICHARDSON and WATT:—

	1	2
Fat acid	50·0	40·0
Potash	11·5	9·5
Water	38·5	50·5
	100·0	100·0

'*Silicated Soaps.*—We have remarked that, commercially, a soap is not necessarily the alkaline salt of a fatty acid, but a salt of an alkaline base, giving with water free alkali. We may therefore in the future look forward to the extension of the soap trade in fresh directions, as chemical laws may dictate. Already the manufacture of silicated soap, in the hands of Mr. GOSSAGE, has assumed a most important magnitude.

'Silicate of soda (or soluble glass) is known, like soap, to hold its alkali in but feeble combination, and, in fact, possesses considerable detergent power. When mixed with ordinary soap, it forms a mixed soap of greatly reduced price, and which is very useful both for domestic and manufacturing purposes.

'For hard soap, Mr. GOSSAGE melts in a reverberatory furnace nine parts of soda-ash, containing 50 per cent. caustic soda, with eleven parts of clean sand; and for soft soap, equal weights of carbonate of potash and sand. These products are dissolved by suitable processes and mixed mechanically with soap paste, forming the so-called silicated soaps.

'Mr. WHITELAW says, if tallow, oil and resin, the matters commonly used in making soap, are heated with excess of common salt, ammonia, and water, a soda-soap separates, leaving in the liquid chloride of ammonium along with excess of free ammonia and salt.

'At first the ammonia combines with the fatty acids, then the sodium contained in the salt takes the place of the ammonia in the soap. An excess of ammonia and soap is essential; 100 parts of tallow require from 15 to 20 parts of ammonia, 20 to 30 parts of salt, and 200 to 300 parts of water.—(*Chemischen Centralblatt.*) *Les Mondes, Revue Hebdomadaire des Sciences*, August 17, 1876.

'Thus far we have attempted to indicate the steps in the processes of soap-making, but the chapter is necessarily little more than an indication of the various plans and processes now in use. In conclusion, we give here some statistics relative to the soap trade:—

'In the year in which the duty on soap was abolished (1852), the total production of soap in Great Britain was equal to 1,600 tons per week, "less than one-half of which was produced in Lancashire" (GOSSAGE.) In 1860 no less than 9,740 tons were exported, but the export trade has fallen off since! In the year 1870 the production of soap in the Lancashire district alone amounted to the total production of 1852; therefore, in 1870 it had increased 50 per cent. (GOSSAGE).'

We have endeavoured in vain to obtain any reliable information as to the present manufacture of soap. Several of the more important manufacturers assure us that no return from the soap-boilers (the *Directory* informs us that there are 77 soap makers in London only) could be relied on.

Our exports of soap of British manufacture in the years 1875 and 1876, as given in the 'Annual Statement of the Trade of the United Kingdom,' compiled in the Custom House, were as follows:—

Previous to the year 1793, soda was obtained exclusively from the ashes of marine plants, the chief quantities being derived from Alicante in Spain, Sicily, Teneriffe, and the coasts of Great Britain. Russian and American potashes were also largely imported. In fact, so large had grown this importation, that during our dispute with America a considerable quantity of saltpetre was consumed in Great Britain to furnish alkali, by heating it with charcoal or other carbonaceous matter (PARKES's *Chem. Essays*). The pearlashes were prepared from potashes by calcination, whereby sulphur and carbon were burnt away, the product being employed for the nicer purposes. These potashes were prepared from the ashes of burnt wood. In the middle of the last century the Russian product was far superior to the American.

The plants above described furnished the soda of Alicante and Carthagena, or (as it was commonly known) 'barilla,' and were sown as seeds in the end of the year and gathered in the following September. So highly was the product valued and the importance of the trade regarded, that by the laws of Spain the exportation of the seed was an offence punishable by death. The plants were mowed down, sun-dried, and burnt on iron bars, over pits 3 ft. deep by 4 ft. square. The ashes fell into the pit, on the floor of which they formed a semi-vitrified mass, which was allowed to cool, then broken into pieces, and in this state formed the commercial article barilla, the best qualities of which contained about 40 per cent. carbonate of soda.

'Kelp' was another commercial soda, and its manufacture on our shores (Wales, Scotland, and Ireland) was introduced from Ireland by MacLEOD in 1730 to the Highlands of Scotland. It is said that Lord MACDONALD of the Isles realised 10,000*l.* a year from his kelp shores alone. British kelp was inferior to the Spanish 'barilla,' seeing it contained more potash, neutral salts, and carbonaceous matter. These rough alkalies were bruised and mixed with quicklime and lixiviated, to furnish the lyes used by soap-makers. They also furnished the supply for the manufacture of glass. According to RICHARDSON and WATT'S *Technology*, kelp is still produced for making iodine and potash salts, while the mother liquors are boiled down to dryness, and yield 'kelp salts' containing from 7 to 14 per cent. of alkali, which are sold to the soda makers. In 1834 there were imported 12,000 tons barilla; in 1850 there were imported 34,880 cwt. barilla; in 1860 there were imported 54,008 cwt. barilla. Scotland alone produced at one time 26,000 tons of 'kelp' annually, so that we did not depend on the Spanish product so much as other countries.

Of late years it has not been possible to obtain the quantity of soda obtained from these sources, and it is much to be regretted that the importation of these articles is no longer given in the Board of Trade returns.

SODALITE. See LAVA, for a report by the Rev. SAMUEL HAUGHTON and Professor HULL on the Microscopic Lavas of Vesuvius. In these traces only of sodalite are found.

SODA NITRATE. MARIANO DE RIVY in 1821 first announced the existence of beds of nitrate of soda in South America.

The natural substance *caliche* occurs in irregular masses, alternating with borate of lime and common salt, at a height of 1,000 mètres.

At Tarapaca, Peru, these beds exist, and they have been discovered in Bolivia—in the south those of Antofagasta, and in the north those of the basin of the Loa. Three samples from the basin of the Loa gave:—

	I.	II.	III.
Nitrate of sodium . . .	51·50	49·05	18·60
Sulphate of sodium . . .	8·99	9·02	16·04
Chloride of sodium . . .	22·08	28·95	33·89
Chloride of potassium . . .	8·55	4·67	2·44
Chloride of magnesium	0·43	1·25	1·62
Carbonate of lime . . .	0·12	0·15	0·09
Silica and oxide of iron . .	0·90	2·20	3·00
Iodide of sodium . . .	—	traces	—
Insoluble matter . . .	6·00	3·18	20·10

The mineral, after being crushed and powdered, is purified by solution, and thus a commercial article obtained containing from 95 to 96 per cent. of pure nitrate of soda.—M. V. L. OLIVIER. *Comptes Rendus*, lxxxi.

There are 131 establishments in Peru, which produce about 300,000 tons a year. The importation into France in the first eight months of 1875 was 44,840 tons.

Our importations of cubic nitre were in 1871:—

	Cwt.	Value
From Peru	2,979,876	£1,793,110
" Bolivia	311,064	181,912
" Chili	23,160	12,700
" other Countries . . .	1,027	614
Total . . .	3,316,027	1,988,420

Board of Trade Returns.

SODIUM, NITRATE OF. The native nitrate analysed by Dr. A. VOELCKER in 1875 averaged 95–96 per cent. of pure nitrate.—*Journal of the Royal Agricultural Society*, 1876.

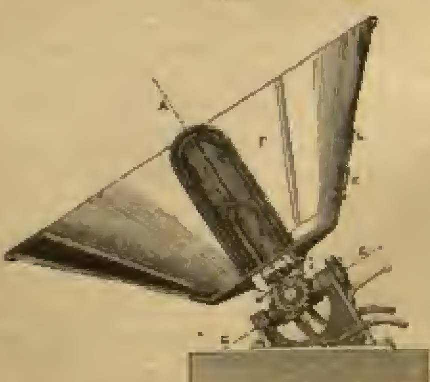
SODIUM SULPHIDE. EITNER recommends the following as the best mode of preparing it:—

Three kilos. of lime are placed in an iron vessel and slacked; after this 55 litres of water and 6 litres of crystallised soda are added, and the mixture heated and agitated. As soon as the boiling commences 1 kilo. of flowers of sulphur is gradually added, and the whole boiled until the liquid assumes a deep golden yellow colour and shows no lumps of sulphur.

This sulphide is used in tanning leather. See TANNING.

SOLAR ENGINE, M. MOUCHOT'S. From time to time attention has been directed to the invention of methods for utilising solar heat, but hitherto a small amount of success has been the reward of much ingenuity. Of late M. MOUCHOT has made some experiments which have been, so far as they were carried, fairly promising. The principles on which the apparatus is based are well known, and we need only, therefore, describe the engine, which consists of three parts, viz., the metallic mirror, the blackened boiler, the axis of which coincides with that of the mirror, and a glass envelope permitting the sun's rays to reach the boiler, but preventing their return. The ratio of the heat utilised with the surface thus isolated, increases with the extent of this surface. The mirror has the form of a truncated cone, with parallel bases, and the generating line makes an angle of 45° with the axis of the cone. This is the best form that can be adopted, because the incident rays striking parallel to the axis, are reflected normally to this axis, and give a heat area of maximum intensity for a given opening of mirror. The reflectors are formed of 12 silvered sectors (*fig.* 2534), F, carried by an iron frame, in the grooves of which they slide. The diameter of the mirror is 112·3 in. at the top and 39·3 in. at the bottom, giving an effective reflecting area of about 45 square feet. The bottom of the mirror is formed of a cast-iron disc, G, to add weight to the apparatus. In the centre of this disc is placed the boiler, B, the height of which is equal to that of the mirror. It is of copper, blackened on the outside, and is formed of two concentric bell-shaped envelopes, H and K, connected at their base by a wrought-iron ring. The larger envelope is 31·5 in. high,

2534



and the smaller 19·68 in.; their respective diameters are 11·02 in. and 8·60 in. The water is introduced between these two envelopes, so that it forms a cylinder 1·18 in. thick. N and I represent the connection with a toothed wheel moving upon its axis, G G, by which the instrument is kept constantly facing the sun. The water in the boiler of this ingenious arrangement is rapidly heated and converted into steam,

which being conveyed through the tube to the piston of an engine, may be used for many purposes.

On the Application of Solar Heat as a Motor Force is the title of a paper which appeared in Poggendorff's *Journal*. The following translation was printed in the *English Mechanic*, from which we borrow it:—

'That the heat of the sun may be transformed into mechanical force no one can doubt, for we see daily what masses of water solar heat raises into the air, to be again precipitated to the earth, and we know what an enormous mechanical force is here represented. Further, we know that solar heat is the cause of motions of the atmosphere, that plants under its influence form out of the carbonic acid of the air an organic substance richer in carbon; that plants which grew in earlier times under the influence of sun-heat were transformed into coal and peat, whose combustion now yields heat to drive our engines, which is simply the solar heat returned.

'But while solar heat is the cause of nearly all mechanical force developed on the earth, we have yet hitherto known of no means whereby it may be directly utilised for mechanical work. It has been proposed, indeed, to employ solar heat, concentrated by lenses or mirrors, for driving a steam or caloric machine. These machines, however, are not suited for this, as they involve too great a waste of heat. Moreover, in concentration a large quantity of heat must be lost. These circumstances, as also the fact that the concentrating apparatus must always be moved according to the motion of the sun, have rendered such machines impracticable. Sun machines must be so arranged that the solar heat absorbed by a given surface may, without too great waste of heat, be directly transformed into mechanical work. We propose to inquire how such a machine may be had.

'It is known that the arrangement of machines which serve for the transformation of heat into mechanical work rests on the principle that a liquid or gaseous substance acted on by the heat undergoes a molecular change, through which a certain mechanical force is developed. The changes of solid bodies under influence of heat are too small for transformation of the heat into mechanical work, or to render them means of movement, although through such molecular change a certain mechanical force is developed. Gaseous bodies have been applied as means of movement in the caloric and gas machines; but with the small differences of temperature which occur in sun machines they cannot be employed as such with advantage. Thus nothing remains but to employ a liquid, and it must be one whose boiling-point is very low. We know that the great expenditure of heat in steam-engines is due in great part to the high boiling-point of water. The higher steam-pressure we have in the boiler the greater is the quantity of heat transformed into mechanical work. Hence, if we had a liquid which at ordinary temperature behaved like water at a high temperature, this liquid would be a suitable means of motion for a sun machine. There are several such liquids, *e.g.* sulphurous acid, methylic chloride, methylic ether, &c. Of all these sulphurous acid best deserves attention, as it has several useful properties for the end in view. It is not too difficult to condense, and it can be got at a moderate price. The keeping of it presents no difficulties, and it may quite well be put in ordinary steam-boilers. Now we have got the principle on which we must construct our sun-machine. Conceive a vessel filled with sulphurous acid exposed to the sun's rays; the tension of the sulphurous acid vapour, if the temperature of this vessel exceeds that of the surrounding air by at least 10° to 20°, must be from 1 to 3 atmospheres higher than that of the sulphurous acid vapour in another vessel B, similarly filled with sulphurous acid, but which has only the temperature of the surrounding air. We can thus arrange an engine which agrees in principle with the steam-engine with merely this difference, that the water is replaced by sulphurous acid and the fuel by the solar heat; while the vessel exposed to the sun's rays represents the steam-boiler, the vessel kept at ordinary temperature may represent the condenser. The sulphurous acid condensed, after doing work in vessel B, could easily be driven back by a force-pump into the boiler representing vessel A. The capability of work of such a machine must naturally increase with the amount of heat communicated to vessel A, or be proportional to the surface exposed to the solar rays.

'If now we conceive a factory or shop, the roof of which is covered with vessels containing sulphuric acid, and which is furnished with a sun-machine made on the above principle, such a machine might indeed work while there was sunshine; but in default of this the establishment would be brought to a standstill. True, the solar heat might be replaced by the heat of the air, if the temperature of the air were pretty high and one had at hand a cooling substance like ice. But as this is not always the case, the establishment should have besides the sun-machine an apparatus which might "store up" some of the work done by this. As such, Natterer's apparatus for condensing carbonic acid might with great advantage be used. If a supply of carbonic acid were kept in a large gasometer, like those in ordinary gasworks, the Natterer

apparatus might be fed from this. In a wrought-iron vessel thus filled with liquid carbonic acid, we should thus have an enormous store of mechanical force, which might be made to replace the action of solar heat in the sun-machine, partially or wholly. After work done the carbonic acid, become gaseous again, might be collected in the gasometer. Or again, the sun-machine while in action might drive an ice-machine, and might, in default of sunshine, profit by the ice it had produced for maintenance of its working.

'We thus see that from the present standpoint of science it is possible to construct a constantly working sun-machine.'—G. A. Hirn: Poggendorff's *Annalen*.

The use of ammonia vapour for the production of power has been advocated by Foucault, and one form of the apparatus devised is to be run by the heat of the solar rays. See Ammonia as a Motive Power.

M. Sallier says his experiments lead him to the result that if evaporation in a glass boiler exposed to the sun is slow, it becomes very active if a metallic nucleus, as a phial of mercury, is placed in the centre, and thus is provided 'in the midst of the water a furnace as exhaustless as the sun.'

Another result is if an oxidisable metal, as iron, is used as a nucleus, the production of oxide is rapid, and consequently the liberation of hydrogen.—*Comptes Rendus Hebdomadaires*, May 1876.

SOMETSUKI WARE. A Japanese ware made at Mino. It is painted blue on white porcelain, with oxide of cobalt under the glaze.

SORGHUM SEED. A genus of grasses belonging to the tribe *Andropogoneæ*. The *S. vulgare* is cultivated in the South of Europe for food. This is a good feeding-stuff, containing 72·44 of extractive matter, 7·47 albuminous matter, and 1·19 nitrogen.—A. Voelcker, *Journal of the Royal Agricultural Society*, 1876. See *Treasury of Botany*.

SPECTRUM ANALYSIS, *applied to Iron and Steel Manufacture.* See Iron and Steel, p. 483.

SPELTER. See Zinc.

SPHÆROCOBALTITE. A cobalt ore. This mineral occurs in spheroidal forms with roselite at Schneeberg, Saxony. The spheroids are coarsely radiated and the surfaces are made up of minute rhombohedral crystals, colour peach-red. Winkler's analysis gave—

Cobaltous oxide	58·80
Lime	1·80
Ferric oxide	3·41
Carbonic anhydride	34·65
Water	1·22
	99·94

Dr. A. Weisbach, *Jahrbuch für das Berg, &c.*, 1877.

SPHÆROSIDERITE. An unusually manganesiferous variety of this mineral found at Felsöbanya and Kapnik, Transylvania. Analysis gives—

Carbonate of iron	53·07
Carbonate of manganese	44·30
Carbonate of lime	1·15
Water	·76
Alumina and silica	traces
	99·34

The chemical formula is $5FeCO^3 + 4MnCO^3$.—F. von Schroeckinger, *Imp. Geol. Instit. Vienna*, April 17, 1877.

SPINELLE. See Ruby.

SPONGE. In the Report of Vice-Consul Jago on *The Trade, Commerce, and Agriculture of the Vilayet of Syria*, it appears that the total value of the sponges fished from the coast of Syria is from 20,000*l.* to 25,000*l.* annually. From 250 to 300 boats are employed, manned by from 1,200 to 1,500 men, and the centres of production are Tripoli, Ruad, Latakia, and Batrun, on the coast of Lebanon. The boats are generally hired for the season, which extends from June to October inclusive, during which months the temperature admits of continual exposure, the comparative tranquillity of the sea and the absence of winds and currents being favourable to the operations of the divers. A good diver will sometimes earn more than 40*l.* a season. Vice-Consul Jago says that diving is practised from a very early age up to 40 years, beyond which few are able to continue the pursuit. Syrian divers can remain under

water from 40 to 60 seconds. They wear no dress, but are provided with an ordinary net round the waist, seize with both hands a large oblong white stone, to which a rope is attached, and plunge overboard. On arriving at the bottom the stone is deposited at his feet, and the man, keeping hold of the rope with one hand, grasps and tears off with the other the sponges within reach, which he deposits in his net. He is then, after signalling by a series of jerks to the rope, drawn up. The depth to which the diver descends varies from 5 to 30 'brasses,' each brass being equal to an ordinary man's height. Two-thirds of the produce of the Syrian coast are purchased by native merchants, who send it to Europe for sale, and the remainder is bought on the spot by French agents, who visit Syria annually for the purpose. France usually takes the great bulk of the finest varieties, and the reddish and common sponges are sent to Germany and England. The revenue derived by the Government from this branch of industry in Syria is one-tenth of the value of the produce calculated upon the prices paid to the finders by the traders, and which is paid in cash by the farmer to the tax farmer on the conclusion of his sale.

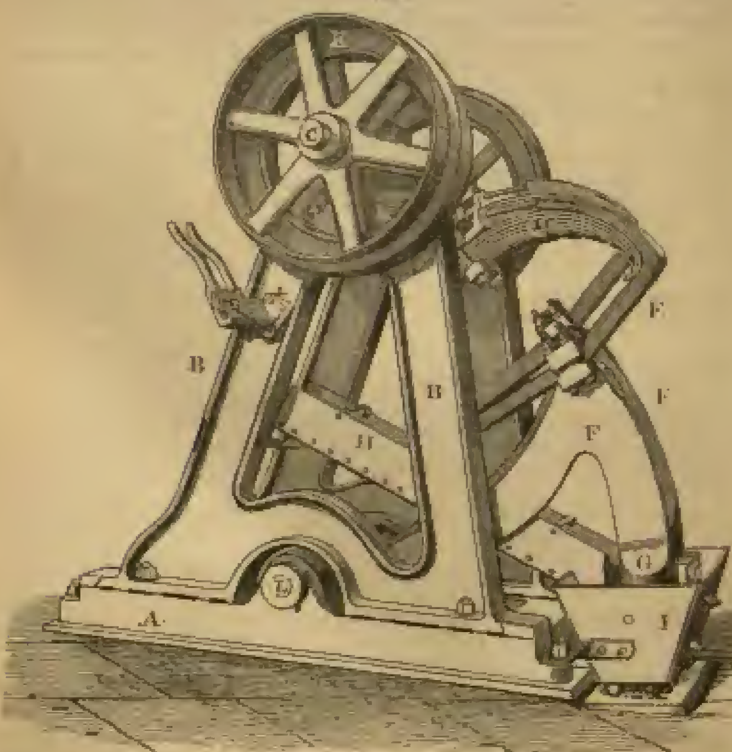
He further states that the crop in 1876 was very deficient, the deficiency being attributable to a fright among the fishermen by the appearance of a sea-monster, 'alleged to have been equal in size to a small boat.' It is stated that this monster swallowed a man whole, but the Vice-Consul gives this tale only 'on the authority of a fellow-worker.' Sales were made in 1876 at the following rates:—

	Piastres
Fine sponge	350 to 650 per oke.
Ordinary sponge	100 ,, 150 ,,
Common red	25 ,, 45 ,,

The 'oke' consists of 400 drams = to 2·841 lb. avoirdupois.

STAMPS, *Elephant Ore.* Mr. John Patterson has lately contrived a simple

2635



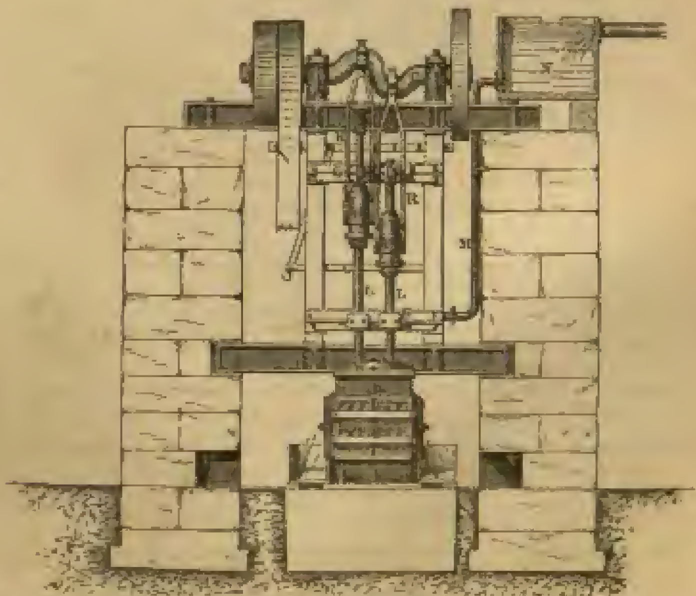
machine for the stamping of ores and other hard substances such as coprolites and

phosphates used in the manufacture of artificial manure, and reducing materials for artificial stone-making. His 'elephant stamps' consist of two or more bent levers connected to a crank shaft by means of semicircular springs and flexible leather or metal connections; whereby the travel of the stamp heads is twice that of the cranks, *e.g.* 7" throw of crank yields 14" travel. The springs, when thus applied, by their peculiar action, store up the recoil after each blow and give the greater part of it out again to increase the force of the next blow on the revolution of the crank shaft. In this machine the velocity can be varied at will and so fracture the hardest rock and reduce it into grains. It has neither guide-rods nor bushes, and the few working parts are quite away from the reach of all dashings of stuff from the coffer.

The stamps can be driven by any motive power by means of a strap, and the consumption of power is reduced to a minimum by the absence of friction and the peculiar economy of power arising from the action of the springs. The power requisite for two stamp heads of 900 lb. to 1,000 lb. each is about five or six horse-power; when driving the crank shaft 120 to 130 revolutions per minute, or 240 to 260 blows per minute, and the length of travel of each head is 12 inches. A ton of hard tin stuff can be stamped per hour. In *fig.* 2535 A is the base plate of machine; B the frame of the machine; C, a crank shaft; D, springs; E, leather connections; F, levers; G, stamp heads; H, passage for stuff; I, coffer; K, driving wheel; L, pin on which levers rotate.

STAMPS, *Pneumatic.* (DRESSING ORES, vol. ii. p. 103.) Most of the processes of ore dressing are based on the relative specific gravities of the metalliferous minerals and the matrix in which they occur. To effect their separation it is necessary to reduce the ore to powder, the fineness of which varies according to the nature and constitution of the mineral. Hitherto nothing has been found more efficient for this purpose than stamping machinery, the ordinary form of which is the old cam stamp used commonly in the county of Cornwall. It consists of heavy heads of cast-iron attached to wrought-iron square shanks or 'lifters;' a projecting tappet or tongue is keyed on to the upper part of the lifters, against which the revolving cam comes into contact, raising the lifter and head and liberating it at a height of about 10 inches; the heavy head falls by its own gravity and impinges a considerable blow on the ore in the coffer; the crushed ore passes through the perforated grate when it is reduced to its proper degree of fineness.

2535



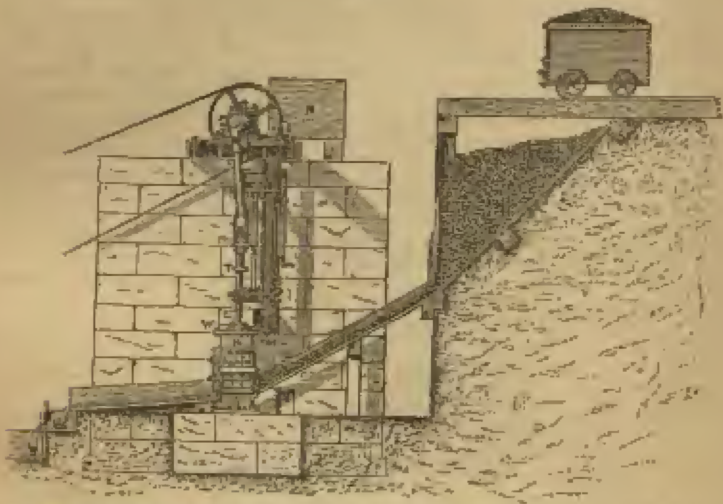
This form of stamps, though good in its day, is far from what is now required in our mining operations; the greatest speed to which these stamps can be driven is about 70 blows per minute, and consequently in tin stamping the heavy particles of

tin ore, although reduced to sufficient fineness to pass through the grate holes, yet not being kept sufficiently agitated, settle to the bottom of the coffer and there become further pulverised; this causes the formation of a considerable quantity of 'slime,' which is far from desirable and entails considerable loss in the further processes of dressing. The capability of these stamps is also very limited; ¾ of a ton of ordinary tin stuff per head in 24 hours is considered about the best duty they are capable of performing. The old form of stamps, to say the least of it, is a rude primitive machine, and something more modern and effective should be looked for in these days of mechanical refinements.

The pneumatic stamps have been devised and constructed capable of efficient and economical stamping, presenting a marked contrast to the cumbrous cam stamps.

As early as 1856 the idea was conceived of employing an air spring or cushion in the working of steam hammers by Mr. Cars, an Englishman; since that time many patents have been taken out for various designs of springs and air cushions. The same principle applied for stamping purposes is employed in the pneumatic stamps patented by W. Husband, of Hayle, Cornwall.

2537



The construction of this stamp will be readily understood by reference to the illustrations, *figs.* 2536, 2537. The air-cylinders, P P, are attached to the two-throw crank, C, by forked connecting rods, R R. The lifters, L L, with pistons, pass through the air-cylinders, and are guided above and below at G G. Cast-iron heads are attached to the lifters and beat on cast-iron grounds at the bottom of the coffer, K. The lifters are made of wrought-iron forged in one with the piston, and having a hole through the whole of its length, down which water flows from the drippers, D D. A water distributor, W, is fixed on the top of the coffer, and is supplied with water by the cistern, N, through the pipe, M. A tappet, T, is clamped to the lifter and works in a gauge, B; this prevents the head from wearing unequally.

The action of the stamps is as follows:—The crank being set into motion by belt from the engine fly-wheel, the cylinder is raised, the air it contains becomes compressed beneath the piston, and the lifter, with head attached, raised to the height of about 14 inches. As soon as the crank turns the centre the compressed air yields back the force absorbed in its compression, and a sharp violent blow is given in the coffer. A stream of water flows through the hollow lifter and discharges just above the head, which serves the double purpose of keeping the piston cool and providing water for stamping purposes.

These stamps are driven at about 150 blows per minute, and one head, weighing with the lifter 3½ cwt., will reduce from 9 to 11 tons of hard tin stuff in twenty-four hours. There is now (1877) at work a single head stamp weighing, with head and lifter, 600 lb., which stamps 1 ton of auriferous quartz per hour.

It is very portable, can be taken to pieces, carried to any part of the mine, and erected with its portable engine in a short time, requiring little foundation, the large

outlay required for the erection of the old stamps being saved. A small battery may be used for prospecting purposes, and worked by horse or bullock power wherever it might be desirable to do so, the machine being made sufficiently portable for loading on a bullock dray.

In mountainous countries, where the roads are bad and transport of machinery to mining districts is expensive and difficult, it is of the first importance that every part of a machine should be as light as possible, so that it may be carried by mules. In the pneumatic stamps this object is easily obtained, and several have been transported in the above manner to gold mines in America and Africa. Several of these stamps have been at work in European and foreign mines.

STARCH, RICE. Rice granules contain more than 80 per cent. of starch, a quantity much larger than that contained in any other grain used for starch manufacture. Where rice can be obtained cheaply the preparation of starch from it is most remunerative, since the granules of rice starch are finer and have a much higher lustre than wheat starch.

Rice starch manufacture is attended with some difficulty, which does not attend the preparation of starch from wheat or from potatoes. The amylum grains from rice are enclosed in firm cellular tissues, and are united by a small but very resisting quantity of gluten, which can only be removed by alkalies or acids.

For the preparation of rice starch we must have clear water, free from organic matter and iron. Sulphate of lime and chloride of magnesium are both objectionable, as these salts decompose a portion of the caustic alkali employed in the process, and caustic magnesia hinders very much the separation of the gluten starch from the fine starch. Caustic soda forms at present the only solvent used for gluten.

Three methods are employed in rice making—the English, the German, and the American; they have, however, much in common.

1. The rice is soaked in caustic soda of 1½° to 2° B. for about eighteen hours, with constant agitation.

2. The swollen rice is washed in clean water twice.

3. It is ground, with addition of 1° B. soda lye, to a fine but somewhat thick liquid pap. This is then agitated for about five hours; it is then pumped into large vessels placed on the second floor of the building. It is then diluted with an equal volume of water and allowed to rest for twenty minutes. By this the largest portion of the gluten starch and cellulose are thrown down to the bottom of the vessel.

The liquid is drawn off by means of a syphon, and water is again added. This is repeated three times, a little calcined soda being added to the water. The milk obtained is passed through a sieve into large tin-plate vessels, where the solid starch is deposited.

After forty-eight hours the liquid is drawn off, the solid taken out, treated with water which has a slight addition of soda, and brought into the centrifugal machine. The above is very nearly Jones's English method. Hoffmann (the German method modified) treats the thin pulp in large vessels with an equal bulk of soda lye of 1° B., allows this to stand for six hours with agitation, dilutes then with another equal bulk of water and allows it to rest for forty minutes. The liquid is then drawn off, and the residue again treated with a very dilute soda ley.

In order to obtain starch in rags, the solid is treated with water neutralised with diluted hydrochloric acid, and, after the addition of a small quantity of ultramarine blue, it is drained on linen cloths placed on boxes. The solid mass is divided into equal large lumps, and these are placed upon porous bricks or plates of gypsum and put into an oven to dry, until no more moisture is seen. The temperature should be from 50° to 60° C., and the damp air carefully carried off for about four days, after which all openings are closed and the starch heated for about two days in a temperature of 75° C. The residue is used for the production of an inferior starch. The yield of fine and secondary starch is said to be over 65 per cent.—M. Anthon, *Deutsche Industrie Zeitung*, 1876.

STARCH, NITRO. See Explosive Compounds.

STATISTICS, MINERAL, OF FRANCE. At page 583 the returns for France give the produce of coal and iron only for the year 1875, and it is stated that 'these are the only returns which can be obtained.' Since these sheets have been printed off I have received, by the courteous attention of M. E. Lamé Fleury, the Minister of Mines, the *Résumé des Travaux Statistiques de l'Administration des Mines*. With this volume, which is very complete, but only for the years 1870, 1871, and 1872, M. Lamé Fleury writes, informing me that the volume for 1873 to 1875 will be published early next year, and that for 1876 in 1879. These volumes record very fully the history of the mining operations carried on in France; but the returns given cease to have any commercial value, they are so much in arrear.

However, by order of the Ministre de Travaux Publics, there has been published in

the *Journal Officiel*, for May 1877, the following statements relative to the coal and iron productions for 1876. M. E. Lamé Fleury informs me that these returns 'sont dressés à l'aide des documents fournis par les Ingénieurs des Mines.' They are of course open to future correction when the returns, which are compulsory in France, come to be examined in the office of the Minister of Mines; but they are sufficiently exact for all practical purposes.

It is thought advisable to give these tables and to explain the cause which leads to their being in this place rather than in the article Mineral Statistics, where they properly belong.

Combustible Minerals produced in France in 1876.

Departments	Products of Collieries			Total
	Anthracite	Coal	Lignite	
	Met. Quint. of 220 lb.	Met. Quint. of 220 lb.	Met. Quint. of 220 lb.	Met. Quint. of 220 lb.
Ain	—	—	6,455	6,455
Allier	63,600	9,951,054	—	10,014,654
Alpes (Basses)	—	253,152	134,902	388,054
Alpes (Hautes)	73,000	—	—	73,000
Ardèche	83,459	42,608	7,223	133,290
Aude	—	—	4,000	4,000
Aveyron	—	7,178,569	45,762	7,224,331
Bouches-du-Rhône	—	—	3,521,100	3,521,100
Calvados	—	113,306	—	113,306
Cantal	—	18,198	—	18,198
Corrèze	—	37,737	—	37,737
Côte-d'Or	26,000	—	—	26,000
Creuse	42,750	2,150,828	—	2,193,578
Dordogne	—	—	3,690	3,690
Drôme	—	—	9,111	9,111
Gard	—	16,427,438	173,636	16,601,074
Hérault	101,665	2,662,766	9,543	2,773,974
Isère	1,123,970	—	21,300	1,145,270
Loire	45,556	34,717,183	—	34,762,739
Loire (Haute)	—	1,776,989	—	1,776,989
Loire-Inférieure	230,000	—	—	230,000
Lot	—	12,097	—	12,097
Maine-et-Loire	441,203	—	—	441,203
Mayenne	947,961	34,454	—	982,415
Nièvre	—	1,626,430	—	1,626,430
Nord	5,808,294	27,347,457	—	33,155,751
Pas-de-Calais	—	33,119,892	—	33,119,892
Puy-de-Dôme	187,713	1,975,222	—	2,162,935
Pyrénées (Basses)	2,000	—	—	2,000
Pyrénées (Hautes)	—	—	10,000	10,000
Rhône	—	332,103	—	332,103
Saône (Haute)	—	1,998,332	113,549	2,111,881
Saône-et-Loire	1,538,225	10,046,687	—	11,584,912
Sarthe	242,719	—	—	242,719
Savoie	226,690	—	—	226,690
Savoie (Haute)	1,717	—	53,117	54,834
Sèvres (Deux)	—	197,043	—	197,043
Tarn	—	2,571,700	—	2,571,700
Var	38,000	122,000	54,000	214,000
Vaucluse	—	—	83,637	83,637
Vendée	—	248,776	—	248,776
Vosges	—	—	31,055	31,055
Total	11,231,612	154,961,021	4,281,980	170,477,613

This being in English tons of 2,240 lb. = 16,745,337.

In the article Iron Manufacture, p. 592, will be found the iron statistics of France

for 1875; having been supplied with the production of iron and steel for 1876, it appears desirable to publish the returns for that year.

France, Production of Blast Furnaces in 1876.

Departments	Smelted with Charcoal	Smelted with a Mixture of Charcoal and Coke	Smelted with Coal	Total
	Met. Quintals	Met. Quintals	Met. Quintals	Met. Quintals
Allier	—	—	947,780	947,780
Ardèche	—	—	806,697	806,697
Ardennes	22,700	—	120,000	142,700
Ariège	—	91,720	177,475	269,195
Aube	1,200	—	—	1,200
Aveyron	—	—	297,230	297,230
Bouches-du-Rhône	—	—	226,000	226,000
Cher	73,180	159,495	118,510	351,185
Corse	48,000	—	—	48,000
Côte-d'Or	23,200	—	87,000	110,200
Côtes-du-Nord	9,350	5,400	—	14,750
Dordogne	54,000	—	—	54,000
Doubs	30,677	—	—	30,677
Eure	—	—	43,520	43,520
Gard	—	—	854,868	854,868
Gironde	55,000	—	—	55,000
Ille-et-Vilaine	19,700	—	—	19,700
Indre	39,970	—	—	39,970
Isère	9,671	—	211,298	220,969
Jura	—	—	297,310	297,310
Landes	162,135	—	—	162,135
Loire	—	—	467,896	467,896
Loire-Inférieure	3,000	—	80,000	83,000
Lot-et-Garonne	8,000	—	120,000	128,000
Marne	—	—	29,226	29,226
Marne (Haute)	117,848	464,977	258,368	841,193
Mayenne	—	20,553	—	20,553
Meurthe-et-Moselle	28,538	—	3,239,421	3,267,959
Meuse	44,100	27,050	105,000	176,150
Morbihan	25,350	—	—	25,350
Nord	—	—	1,486,525	1,486,525
Pas-de-Calais	—	—	602,390	602,390
Pyrénées-Orientales	79,074	—	—	79,074
Rhône	—	—	697,937	697,937
Saône (Haute)	128,735	—	—	128,735
Saône-et-Loire	—	—	1,506,924	1,506,924
Sarthe	—	8,422	—	8,422
Savoie	2,850	—	—	2,850
Tarn-et-Garonne	—	53,500	—	53,500
Total	977,268	751,117	12,766,992	14,495,377

Equal to 1,423,653 English tons.

The production of merchant iron in France in 1876 was as follows:—

From charcoal	185,021	metrical quintals of 220 lb.
" " and coke	162,665	" "
" coal (rails)	774,201	" "
Other than rails	6,210,826	" "
	7,332,713 = 654,700 English tons.	

The production of steel (iron and plates) in France in 1876:

From charcoal iron	120,519	metrical quintals of 220 lb.
" charcoal and coke iron	91,952	" "
" coal or coke	938,896	" "
	1,151,367	" "

Production of Steel in France in 1876.

Departments	Forged Steel	Puddled Steel	Bessemer and Martin Steel	Cementation Steel	Total	Cast Steel
	Met. Quin.	Met. Quin.	Met. Quin.	Met. Quin.	Met. Quin.	Met. Quin.
Allier	—	—	214,360	—	214,360	—
Ardennes	—	—	—	160	160	170
Ariège	500	16,509	—	1,011	18,020	214
Charente	—	—	7,700	—	7,700	—
Côtes-du-Nord	—	175	—	73	248	109
Finistère	—	—	—	—	—	41
Gard	—	—	270,510	—	270,510	—
Garonne (Haute)	—	—	—	8,400	8,400	—
Isère	1,660	44,800	7,230	1,430	55,120	1,240
Loire	—	110,672	720,616	10,451	841,739	68,604
Meurthe-et-Moselle	—	10,060	—	—	10,060	—
Nièvre	—	3,814	59,017	—	62,831	—
Nord	—	—	206,357	—	206,357	8,875
Rhône	—	—	172,304	—	172,304	—
Saône (Haute)	—	—	—	228	228	206
Saône-et-Loire	—	—	569,028	—	569,028	—
Seine	—	—	575	—	575	—
Tarn	—	—	—	631	631	—
Total	2,160	192,087	2,319,967	27,904	2,541,906	78,880

STEAM BOILERS DISINCRUSTED BY ZINC. See Zinc as a Disincrustant; see also Petroleum.

STEEL, DEFINITION OF. 'M. Gruner, in 1870, endeavoured to settle the definition of steel, when he reserved that name for "all malleable products obtained from iron ores, in a state of fusion." He quotes the definition adopted by M. Gruner, that steel, whether cast or not, is any iron, more or less pure, susceptible of being hardened, but which is malleable, hot or cold, so long as it has not been suddenly cooled; whilst soft iron, whether cast or not, is iron which is malleable, hot or cold, and is not susceptible of being hardened. According to this definition, it is evident, the essential attribute of steel is its capacity for being hardened; but, the author remarks, certain puddled irons may be hardened as well as certain steels, and also certain cast irons.

'Again, there is the capacity for being welded, which is intimately related with that of hardening; the irons and steels which receive a temper, or hardening, possess little or no welding property.

'In fine, a definition based simply on the property of tempering would cover too limited an area, and would exclude, for example, the phosphorous steels—a class of steel of recent origin.

'From these and other considerations, the author maintains that the essential distinction between iron and steel must be based on the structure of the metal; by which he means that homogeneity and density in virtue of which steel possesses a much greater tensile strength than iron.

'M. Philippart agrees with M. Gruner, that the name of steel should be reserved for the homogeneous products obtained by fusion; and he gives the following *résumé* of tests of tensile resistance of iron and steel manufactured by Cockerill, of Seraing:—

	Resistance to Rupture: Per Square Millimètre	Per Square Inch	Extension
Superior fibrous iron, No. 5	40 kilos., or	25·39 tons	15 per cent.
Steely iron, puddled steel (mean results)	48 ,,	30·47 ,,	7·5 ,,
Bessemer steel	70 ,,	44·44 ,,	12·5 ,,

'From this statement it appears that puddled steel is not much stronger than fibrous iron. The small difference is due, in a great measure, to the difficulty of obtaining a perfect union of the particles of puddled steel—a contingency which is not met with in intimately fused products. Hence it is that M. Philippart maintains that the term steel should be restricted to melted products. The name of puddled steel might well be replaced by the name granular iron, or steely iron—the adjective "steely" indicating in this case that the metal is susceptible of being hardened, like certain qualities of cast steel.'—*Definition of Steel*, by A. Gruner and

M. Philippart, *Annuaire de l'Ass. des Ing. Sortis de l'École de Liège*, May and June 1875, pp. 222–260.—*Abstracts of Papers* for Institute of Civil Engineers.

Disengagement of Ammonia.—M. Barré has repeatedly observed at the Steel Works of Anina the disengagement of ammonia on the rupture of certain bars of steel. He states that hard steel gave off a quantity of ammonia sufficiently strong to be recognised at some distance. Red litmus and turmeric paper on being applied to the fracture, immediately changed colour, the former to blue and the latter to brown. If the broken surface was moistened, bubbles of gas were seen escaping for a quarter of an hour. With softer steel the escape was less manifest, but could be detected by test-paper. The steel made in the gas furnace by the Siemens process exhibited this phenomena most decidedly, but it was also recognised with Bessemer steel.—*Comptes Rendus.*

STEEL, CHROMIUM. See Iron (vol. ii. p. 918); Steel (vol. iii. p. 804.) Sergius Kern, of the Obouchoff Steel Works, St. Petersburg, communicates to the *Chemical News* a paper on the 'Production of Chromo-steel.' All matters of real importance in relation to the manufacture of iron and steel will be found in the volumes referred to above, and in the article Iron and Steel, p. 451 of this volume. The following paper, dealing with a new combination, we transfer to our pages without curtailment:—

'Most of the crucible steel is at present prepared by melting in fire-clay crucibles suitable mixtures of puddled steel, iron, steel or iron filings, with the addition of iron magnetic oxide as a flux and ferro-manganese in order to reduce the oxides of iron resulting from the oxidation of the melted metal. When hard steel—the so-called instrumental steel—is desired, the iron or iron filings are replaced by refined cast iron in the above-mentioned mixtures. The bars of puddled steel before being cut into pieces (1 in. by 1 in.) are ordinarily classified by their degree of hardness; this is done by breaking them by means of a hammer. But as the puddled bars are never uniform in respect of the percentage of carbon, the production of a required percentage of carbon in cast steels is a rather difficult task. The following tables show to some extent the fluctuation of the percentage of puddled steels obtained by the ordinary way and by rolling the puddling blooms into bars. The combined carbon was determined by the Eggertz calorimetric method. The normal steels were tested by the oxidation of the carbon of steels by chromic acid, and next collecting the resulting carbonic acid in a potash apparatus. It must be mentioned that puddled steel for the preparation of crucible cast steel is always puddled with wood previously dried in suitable furnaces, in order to avoid the use of coal, containing more or less sulphur. The use of such fuel certainly increases the price of the steel blooms.

Table of Analyses of Steel Bars.

Sets of Hard Steel Bars.	Carbon		Sets of Soft Steel Bars.	Carbon	
Bar	I.	II.	Bar	I.	II.
A	0·77	0·56	A	0·18	0·18
B	0·77	0·58	B	0·18	0·22
C	0·51	0·31	C	0·22	0·18
D	0·58	0·31	D	0·22	0·18
E	0·58	0·31	E	0·47	0·18
F	0·70	0·31	F	0·27	0·18
G	0·51	0·58	G	0·47	0·27
H	0·79	0·51	H	0·18	0·18
I	0·51	0·51	I	0·47	0·18
J	0·61	0·58	J	0·22	0·22
Mean			Mean		
near to	0·63	0·46	near to	0·29	0·20

These analyses are only a few representatives of analyses of such kinds of bars in my hands; they clearly show why the metallurgist is always blind in mixing raw materials for the preparation of cast crucible steel. The use of Bessemer or Siemens-Martin steels avoids this difficulty very well; these steels are far cheaper than puddled steels.

'The following experiments were made in order to prepare solid steel without blow-holes by the crucible process, which would give a good resistance and a proper elongation. The use of the rather dear ferro-manganese was avoided, and the only substitutes of it in the new process are ground chrome ironstone ($FeOCr^{2}O^{3}$) and limestone previously calcined.

'The annexed tables (A and B) show the composition of raw materials and receipts

for the preparation of chromo-steel for various purposes. This steel is especially suitable for steel-casting direct in earth-moulds:—

(A.) Analysis of Raw Materials for Casting Steel.

(a.) Bessemer *Rolled Steel Bars.*

	I. Per Cent.	II. Per Cent.
Combined carbon	0·100	0·250
Silicon	0·006	0·010
Manganese	0·020	0·030
Sulphur	traces	0·005
Phosphorus	0·010	traces
Copper	none	none

(b.) Siemens-Martin *Rolled Steel Bars.*

	III. Per Cent.	IV. Per Cent.
Combined carbon	0·400	0·600
Silicon	0·020	0·020
Manganese	0·030	0·130
Sulphur	0·010	none
Phosphorus	traces	0·001
Copper	traces	none

(c.) *Iron.*

	Per Cent.
Combined carbon	0·12
Graphite	traces
Silicon	0·02
Manganese	traces
Sulphur	none
Phosphorus	none

(d.) *Refined Cast Iron.*

	Per Cent.
Combined carbon	4·25
Graphite	0·10
Silicon	0·03
Manganese	0·01
Sulphur	none
Phosphorus	none

(e.) *Chrome Ironstone.*

	Per Cent.
Chromium oxide	65·51
Ferrous oxide (FeO)	31·65
Sulphur	none
Foreign matter	2·00
Copper	none

(f.) *Lime Calcined.*

	Per Cent.
Calcium oxide	90·750
Silica	1·500
Iron oxide	2·750
Sulphur	0·010
Phosphorus	0·005

'The chrome ironstone and limestone are calcined and next ground. The raw metallic materials are used for preparing the steel in the form of pieces of a square form (1 in. by 1 in.). Raw products having closely the above-mentioned composition, may be used for the further receipts for the preparation of cast steels.

(B.) Receipts for the Preparation of Cast Steel.

	I. Kilograms	II. Kilograms
Bessemer steel, No. I.	24·00	10·00
" " II.	5·00	22·00
Iron	5·00	2·00
Chrome ironstone	0·75	0·65
Limestone	0·25	0·35

'The percentage of carbon in the received steels is about 0·20 to 0·25 in steel in No. I., and 0·45 to 0·55 in steel in No. II.

	III. Kilograms	IV. Kilograms
Martin steel, No. III.	20·50	2·00
" " IV.	4·50	10·00
Refined cast iron	8·75	12·00
Chrome ironstone	0·75	1·25
Limestone	0·50	0·75

'The percentage of carbon in the received steels is 0·80 to 0·90 in steel No. III., and 1·0 to 1·3 in steel No. IV.

'The mixture for steel-preparing is placed into previously heated fire-clay crucibles; the chrome ironstone and the lime are placed on the bottom of the crucible, and next it is filled with the other materials entering into the composition of the receipt. Ordinary coke-crucible or Siemens gas crucible furnaces are used for the operation.

'The resulting four numbers of steel are quite sufficient for nearly all purposes, as following:—

Steel No. I., for steel plates, rifle barrels.
" II., for machinery parts, cannons, tires, axles.
" III., for instruments, cannon rings, saws.
" IV., for chisels, planing tools, &c.

'The annexed table shows the mean result of the mechanical tests of the above-mentioned steels. The steel ingots obtained were hammered to test bars, which, after forging, were cooled in water. From every number of the cast steels mentioned in the tables, six different specimens were examined.

Cast Steel, No.	Percentage of Carbon	Tons per square inch		Elongation in Inches
		Begins to Stretch	Breaking Weight	
1	0·23	25·3	48·1	1·35
2	0·49	26·1	49·2	1·21
3	0·95	24·8	52·3	1·13
4	1·20	27·1	54·7	0·62

'The samples of steels contain 0·08 to 0·25 per cent. of chromium; as ordinary hard steels contained more chromium than the soft specimens.

'In preparing steel by this process the use of manganese alloys is avoided, which in many cases, while reducing the iron oxides, give steel containing phosphorus and sulphur, as these elements are found in the ferro-manganese very frequently. By the new process cast steel of a very good quality may be had at very moderate price.'—*Chemical News.*

STENOCHROMY. See Printing in Colours.

STIBINE. (*Antimoniuted Hydrogen.*) Owing to the difficulty of freeing stibine of hydrogen, and to the fact that it spontaneously decomposes, even at ordinary temperatures, its exact composition has never been ascertained. Jones (*Journal of Chemical Society*, May, 1876), describes his analysis, and concludes that SbH^3 is the correct formula for stibine. He found the reaction of this gas on sulphur so delicate a test for light, that he made photometric and photographic experiments with it, and he says it is an excellent test for antimony.

STIBNITE. See Antimony.

STIRLINGITE. The name given to a mineral found associated with Franklinite, on Stirling Hill, Sussex County, New Jersey. It is a zinc chrysolite, and has

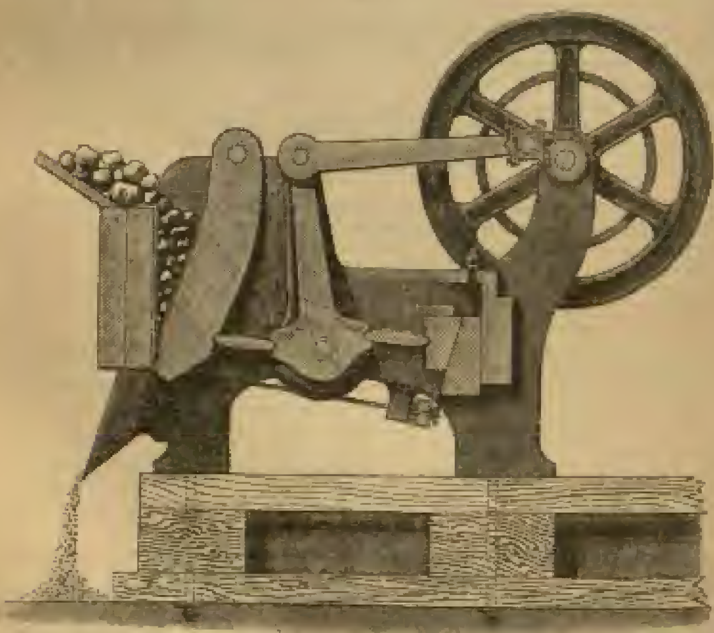
been analysed by RORTTEN (WATTS's *Dictionary of Chemistry*, 1870, p. 392). It was named by KENNGOTT (*Jahrbuch f. Mineralogie*, 1872).

	1	2	3
SiO^2 . . .	30·76	29·30	30·67
FeO . . .	33·78	35·60	35·37
MnO . . .	16·25	16·90	17·81
ZnO . . .	10·96	10·64	9·87
MgO . . .	7·60	6·81	5·60
	99·35	99·30	100·80

STONE BREAKERS AND ORE CRUSHERS. In vol. iii. p. 918, a short notice of these machines is given. They have since the date of that notice come so generally into use, that it appears necessary to supplement it by another.

The stone breaker (*fig.* 2538) was invented by ELI W. BLAKE, and has been made for many years by the late H. A. MARSDEN, of Leeds who introduced several improvements.

2538



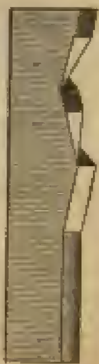
The characteristics of machinery of this kind, to constitute a really good machine, are, that there must be no toothed gearing about it, and that friction must be reduced to a minimum by a judicious arrangement of parts. As such machines are of great use, and are extensively employed in distant colonial settlements where no foundry or workshop is at hand, of course they must not be likely to break down in any part. The moving jaw is actuated by an ingenious contrivance. On the back of the moving jaw is a horizontal semi-circular recess: at some distance, say about two feet from this, there is a corresponding recess in a block in the frame casting that carries the fly-wheel, its shaft, and bearings. A part of the shaft between the bearings is eccentrically turned, and a strong rod or bar, with a bearing hole in it, is fitted on this part of the shaft. The rod hangs down between the two recesses already described, and has its lower end made thicker and stronger than its body part. In this lower end are

two semi-circular recesses, similar to those in the jaw and frame. The rod is such a length that when the eccentricity of the shaft has been turned so as to lower the rod to the lowest, these notches are below a straight line which we may imagine to be drawn from the jaw recess to that in the frame block. Two toggles are placed with their ends in the notches, one between the jaw and the rod, the other between the rod and the frame. The jaw is kept drawn back against the rod by a spring, whose action resembles the spring which keeps the jaws of a smith's vice ever tending to open.

The action of the machine is this: when the fly-wheel and shaft are caused to rotate, the eccentric part of the latter draws the rod or bar up and pushes it down. When the bar is raised it draws up the ends of the two toggles, or as they may be aptly termed, the knuckle-bars. As they are drawn up, they, of course, approach the straight horizontal line, and as the one pivoting in the notch or recess in the resting block cannot go back, the jaw is therefore forced forwards towards the fixed jaw, crushing at the same time any piece of stone resting between them both.

It has hitherto been open to the objection that the stones, being always cracked in the same direction, were not brought into the best shape, but, by a recent improvement in the shape of the jaw, the stone is now cubed, and an excellent sample of road metal is prepared with far less waste of material. The contrivance for cubing the stone by means of a cross-bite (*fig.* 2539), near the bottom of the jaw, and still more clearly in the front view (*fig.* 2540), where it will be noticed that the partially broken stone, instead of descending in one straight line, will be thrown sideways, by the change in the grooving of the surface of the jaw. The movable jaw is suspended on a pin, and is moved by the rocking lever between the two toggles. The thrust is upon the lower part of the jaw, and is greatest when the lever is in a vertical position and the two toggles are in the same straight line.

2539



2540

An improved 'cubing' jaw is the most recent addition to the efficacy of these machines, for use when it is desirable or essential that the reduced material should be well and evenly broken up to a regular gauge and cubical form, as more particularly in the case of road metal. The construction of this jaw is simple, and consists in an extension of the lower end, and giving a curved form backwards to the movable jaw; thus the orifice of delivery is made to terminate a parallel channel of some three or four inches in length, wherein the corrugations of the fixed and movable jaws are so arranged as to alternate the one with the other, *i.e.* ridge against furrow, and *vice versâ*, and the action of this jaw leaves little to be desired in regard to the evenness and regularity of the resulting sample of broken stone—whence it is called cubical.

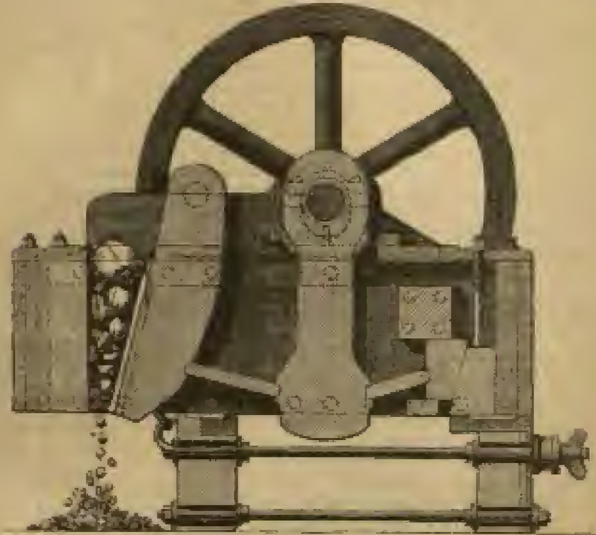
The new features are that the top sections of the jaw are of much coarser pitch of teeth than the lower section. Each section is made to turn end for end when the teeth are worn off; they are therefore reversible. They are cast on chills with the hardest mixture of metal, but have wrought-iron bars cast at the back, so as to be easily fitted or planed. The white metal joint is entirely done away with, a soft cast-iron plate with planed fitting strips on one sides, against which the fixed jaws bear, being substituted. The jaw stock is also planed. The lips in the swing jaw are slightly undercut, and so the wedge piece draws them by forcing them outwards, and is held by lock nuts and pin at the back, whilst a recess and tongue hold each section sideways.

The top sections have their teeth arranged ridge and furrow, the bottom sections tooth and tooth fashion. The lower sections are recessed back, so that the first part of the operation is to ledge the stone. It drops into the cavity, and is finally squared or cubed at the bottom. It is also more tumbled about and is put into a better form for smashing by the break in the jaw ribs. The bottom sections can be reversed without the top, and *vice versâ*. The pitch of the teeth at the bottom is 1½ in., 1¾ in., 2 in., 2¼ in., and 2½ in., depending on the size of the road metal, but the general and most useful size is 2 in.

Fig. 2541 is another and very useful form of Marsden's improved machine. The general action of this machine requires scarcely any description, as it is already well known to most of our readers. The lumps or nobbles of stone are flung into the widely-gaping upper mouth of the crushing jaw. The stones, by their own weight,

fall into this jaw when open, and are thus readily crushed by the closing thereof. The operation of the crushing jaw is effected by the now well-known toggle joint, or

2541



elbow levers—in which an enormous strain, gradually culminating to infinity at the ultimate length of stroke, may be produced in a most simple and effective way. The broken metal or ore then falls into, in some cases, a revolving riddle. The riddle is pierced with a successive series of holes, the smallest at the top, through which the fine dust and chip first fall. As the descending pieces then pass down the length of the riddle, the different-sized lumps pass through the smallest set of holes that will admit of their passage. The resulting metal is thus most perfectly sorted into samples, which will pass through certain-sized holes. The pieces that will not pass the riddle are delivered out at the end, and may be re-crushed if not suitable for use.

In a specimen of stone-breaker now made by Mr. Marsden, the frame and eccentric shaft have been constructed much stronger and the fly-wheel heavier, in order to meet the wants of large quarry-owners breaking Guernsey, Jersey, and Leicestershire granite. This machine will break sixty tons per day into good road metal with ease.

In order to meet a demand amongst chemists and metallurgists, Mr. Marsden makes smaller hand and power machines. One combination he uses is worked by a vertical lever in combination with a crank and connecting rods, the toggles being held in the lever, one on either side, and taking into a notch on the swing jaw, whilst the other rests in a notch on a toggle block at the back. The lever fulcrum works in dies in a slot at each side of the frame, and is free to move horizontally, as the toggles lengthen or shorten by the various angles they assume in consequence of the revolution of the crank. This is a double-acting machine, the operating jaw vibrating twice for each revolution of the crank.

The machines are also sometimes made with wrought-iron frames in order to decrease the weight of transport where roads are bad or wanting.

Fig. 2542 represents a very interesting description of these machines especially constructed for the use of mines. This machine has given considerable satisfaction for breaking ores, quartz, fossils, flints, coprolites, &c., down to one uniform size. The object of this particular form of the machine is to simplify the plant of anyone having to deal with hard substances, and to reduce these substances to powder and fine gravel without the possibility of large and flakey pieces being intermixed with the resulting sample. Take, for instance, miners', pottery, Dinas, and gannister clay, fire-brick manufactures, chemical works, ironworks, &c., where the principle of disintegration, both of ores and fuel, in order to combine the same more intimately for reduction, is carried on.

The machine, as shown, fitted with a sorting table, around which the boys are at work, can be made in all sizes, but it is preferable to take a size which practice has

determined the best—say, 15 by 9 in. This will reduce to about ¾ cubes 80 tons of ore stuff per day.

2642

In Cornwall are to be seen rolls working with the raff wheel, and returning the stuff that will not pass the screens to be re-crushed. This is exactly the position of this machine. All the material passed through the BLAKE machine is not necessarily reduced sufficiently the first time, but to accomplish this without further manual labour a shaking screen or riddle is interposed between the delivering orifice and the raff wheel, which screen delivers the fine below, and passes the coarse into the wheel, which is of cast-iron and wrought-iron arms, having internal buckets, to elevate the stuff and feed it into the mouth again. Practical miners have pronounced this arrangement excellent, and one greatly wanted, especially in making trials on the opening of new mining properties.

The machine weighs about 6 tons 10 cwt., and costs, we understand, 50 per cent. less than present machinery to do the same work.

ARCHER'S *Stone-breaker.*—A modified form of these machines has been introduced by Mr. ARCHER, and are manufactured at the Dunston Engine Works, Gateshead. The peculiarities of this stone-breaker are: the movable jaw is suspended from the upper end, and receives its motion from a crank-shaft operating through a powerful lever. An eye-bolt running loosely through the lever, to the back of which it is securely fastened, is substituted for the spring formerly used to return the swing-jaw, and which was the cause of considerable trouble through becoming weak, and, consequently, useless. The size of the fragments is regulated in an ingenious way. The rod connecting the lever to the driving crank is, by the insertion of a liner of the requisite thickness between the two plummer blocks, shortened or lengthened as occasion may require; and the position of the movable jaw being thus altered at pleasure, the machine is rendered available for different classes of work. Clogging also is effectually prevented by a horizontally fluted roller placed below the fixed jaw, which breaks into cubes any piece of stone or ore that may escape the jaws. Various motions can be given to the roller, according as the nature of the work requires. In ore-crushing, when the material is to be pulverised, the roller is made to revolve regularly, producing a grinding action between it and the lower jaw. For breaking stone into road metal this rotary motion is made intermittent, when the broken fragments free themselves from the grip of the machine and fall free from

dust. At the same time, sufficient dust is formed to bind the metal when spread upon the road. The arrangement by which this effect is produced consists of a strap placed round a sheave keyed on the axle of the roller. A pawl working on a pin connecting together the two extremities of the strap, has its outer arm attached to a rod from the crank shaft, the inner arm or pawl riding over the sheave when taking the backward motion, but directly the forward motion is made, which is coincident with the backward motion of the movable jaw, the pawl grips and fastens the band tightly round the sheave, causing the roller to revolve to the extent regulated by a set-screw.

The special and peculiar advantages of these machines may be thus briefly enumerated. The centre of the chief working parts is in one vertical line, which effectually prevents rubbing on the surface of the thrusts, and enables the toggle gear, necessary on other machines, to be dispensed with. A considerable saving of driving power is effected by the return stroke of the lever bringing the swing jaw with it, and, as has been already shown, in dispensing with the expensive and troublesome springs necessary in other forms of stone-breakers. The fluted corrugations of the revolving cubing jaw being at right angles to, or crossing the flutes at the bottom of the swing jaw, have the effect of cutting the materials into cubical and uniform pieces, and any flat pieces lying between the cubing and swing jaws become split or broken by the upward motion of the latter. By the substitution for the stone-breaking roller of one with fine flutings and setting the jaws closer, the machine becomes adapted for grinding.

Hall's *Improved Stone-breakers.*—The machine introduced by Mr. Hall, of Sheffield, has the main leading features, and hence the distinctive advantages, of the old 'Blake' machine, but by the introduction of a duplex or multiple action of the breaking jaws, several material improvements appear to have been effected. In the ordinary 'Blake' machine the breaking jaw is all in one piece, and therefore does the whole of its work in a single half-revolution only. Owing to the magnitude of the resistance to the crushing jaw, this irregular action of alternate work and no work in the single revolution can only be rendered tolerably regular, so as to be obtained successfully from a rotary motion, by the use of a heavy fly-wheel. This not only means a large amount of metal, which costs money, but also a large diameter, which has sometimes been found inconvenient.

In the machine made by Mr. Hall the jaws are divided into two parts, which are driven by eccentrics and toggle joints, so as to crush in alternate portions of the revolution of main shaft. This arrangement, it will at once be seen, reduces the maximum pressure to half that which would be caused in a machine with a single crushing jaw, equal in width to the two alternate jaws of this machine. Hence the whole proportions of the multiple action machine may be made much lighter for a given amount of work than could be the case with a single-jawed machine.

By this duplication of crushing jaw the work is balanced upon the main driving shaft, so that a regular speed of rotation may be obtained with a fly-wheel, light and of small diameter. This tends to reduce the oscillation and vibration of the machine, and so far as it saves the wear and tear of the driving engine, effects an economy of power. This reduction of irregularity in motion will also be of advantage to the life of the driving engine. To further increase the steadiness of working, the base of this machine is spread over a larger area, and when fitted, as every improved breaker can be, with travelling wheels, the wheel-base area is exceptionally large. The wheels are also made broad, and of great strength, to allow of rough usage over uneven ground. At the same time they are rounded on the face, so as to give the least resistance on smooth and level roads.

The construction of the wearing face is specially calculated to allow of easy renewal and to give the best cubing effect. The moving jaws have a raised projection, which is chilled at the top cast across the face; this is undercut at each side, and suitable cubing faces are let in, and held at the top and bottom by wedge-shaped bolts, which can easily be tightened to take up slack or loosened to allow of removal without disturbing any other part. The fixed jaws are also fitted with two movable faces, which can be renewed or altered with ease, and all the faces are reversible, so as to present two wearing surfaces. It is well known that the wear is greatest at the lower end of the working jaw, and this is the smallest of the removable faces in this machine, so that it is certain the top faces will wear out two, or even three, sets at the lower end. It is found that the opposing movement of the multiple or duplex action is very valuable for giving a side rolling motion to the stone or mineral.

In view of the best possible production of road-metal, a double action is performed by each jaw in its upper and lower portions respectively. The upper portion has teeth of a coarser pitch than the lower face, and works with a tooth on one side opposite a space or recess on the other, so as to get a sledging action on the large

blocks, and thus break them with the least expenditure of power. The lower faces are of finer pitch, to suit the size of road-metal, and work point to point in order to cube it properly. The enlarged throat, which has been introduced between the two faces, and the receding action of the neighbouring jaw, give special facilities for the rapid manipulation and easy getting away of the broken metal, so that the proportion of splinter and dust is but small. The sum-total of useful effect in the improved stone-breaker is claimed to be higher, and the percentage of disadvantage smaller than in its predecessors.

KNIGHT *and* FARINAUX'S *Machine*.—Messrs. KNIGHT, FARINAUX, and DUTEMPLE, of Lille, have introduced a stone-breaking machine. The novelty of their machine consists in arranging and combining together side by side a series of separate strong levers operating like shears to cut or split the pieces of stone that are to be broken, instead of employing hammers or other known means and instruments for effecting that object. In a suitable framing they arrange side by side two sets of levers, one set being placed opposite to the other set, each side being inclined so as to present a wide opening at the top to receive the pieces of stone, and a narrow opening at the bottom. Each set of levers is mounted on a separate horizontal axle, which passes through holes of corresponding size made in each of the separate levers of each series.

The upper and lower ends of each of the levers is formed taper on its opposite edges, the taper edges constituting cutting edges, operating like shears employed to cut metal. The levers are corrugated on those parts of their edges which are between the plain tapered parts or cutting edges for securely holding the pieces of stone while they are being broken. Upon two strong horizontal shafts a metal tube, having cams or projections formed on its surface, is fixed, each cam corresponding to its respective lever at the back edge thereof and bottom ends of the said levers; rotary motion is imparted to the aforesaid shafts and cams by a system of toothed gearing driven by any convenient and suitable means.

In this machine the pieces of stone to be broken are placed in a hopper at the top of the machine and fall between the innermost corrugated edges of the two sets of levers: as the cams are caused to rotate the lower ends of the opposite sets and series of levers will be forcibly pressed, and approach each other and effect the breaking or splitting of the stones that are between the corrugated edges of the several levers, after which the pieces of stone thus broken will fall down, and be caught between the plain cutting edges of the several levers, and thus be finally cut and finished. An important feature in this invention consists—firstly, in combining in one machine the operations of two separate machines, and, secondly, by making each of the aforesaid levers with four separate cutting edges; when one cutting edge is worn, by turning these levers upside down, or the back edge to the front, four new cutting edges may be brought into use, thus effecting great economy in the cost of machines of this description, as also economising power and space, and more effectually breaking the stone than has heretofore been accomplished.

STOPPERS FOR AËRATED WATERS. Messrs. BARRETT and ELERS patented a few years since a stopper formed of a stem of lignum vitæ, around which was a ring of india-rubber. This being in the bottle, is pressed against the shoulder of the bottle like a valve—the greater the pressure of the carbonic acid gas the more closely is the india-rubber ring fitted. The bottle is opened by forcibly striking down the stick of lignum vitæ, which remains in the bottle until it is again filled.

The frequent use of the same piece of wood was objected to. The patentees have now substituted a glass bullet, with a very small disc of india-rubber fitted to its centre.

By adapting this to LAMONT'S patent bottles, which are all of exactly the same size in the mouth and rimmed on the inside, these stoppers will fit accurately in every case, and can be instantly opened by the use of a cap, which will force the glass stopper into the bottle. These stoppers, of course, remain in the bottle, and are readily cleaned with it. The saving of time in corking and wiring is very great, and the security is much greater than that furnished by the best cork.

STRAW. (*Paille*, Fr.; *Das Stroh*, Ger.) Portable engines arranged for burning straw have become of great importance for agricultural purposes. A great number of satisfactory trials were made at the Vienna Exhibition. These proved that 1 lb. of straw is capable of evaporating from 1·81 lb. to 1·97 lb. of water into steam of 70 lb. pressure and 305·6° Fahr. These trials were made under the most favourable circumstances. (See FUEL.)

STRONTIAN. (Vol. iii. p. 923.) M. DIEULAFAIT communicated to the Academy of Sciences a paper on the occurrence of strontia, from which we glean the following interesting particulars:—

Strontian exists in the water of the sea in the states of carbonate and sulphate

In the state of carbonate it may be recognised in 100 cubic centimetres of sea water. In the state of sulphate it appears distinctly in 4 c.c. of the waters of the Mediterranean, Red Sea, Indian Ocean, China Sea, and Atlantic Ocean.

The gypsum which in salt marshes forms in abundance on the tables before the deposit of the marine salt, contains strontian in sufficient quantity for the milligram of this gypsum to give, in a perfectly distinct manner, the spectrum of strontian.

In the spontaneous evaporation, on a large scale, of sea water, strontian is concentrated in the first precipitate (carbonate of lime), but chiefly in the second (sulphate of lime). This is why it is not met with in the products which are formed later—namely, marine salt, chloride of potassium, and magnesium, nor in the last mother-lye.

We have seen that the carbonate and sulphate of lime in solution in sea water contain strontian. All the limestone forming the mineral parts of marine beings is necessarily borrowed from this source; hence this limestone part must always contain strontian. This has been fully verified by experiment. In all these calcareous parts the strontian is distinctly recognisable with a weight which has never exceeded 1 centigram.

If the ancient seas had, from the first, a composition similar to that of our modern seas; if they contained, and in the same proportions, substances hitherto thought very rare, like strontian, then we should find strontian in the mineral non-modified parts of beings which have lived in the seas at different epochs. Observation has quite justified this. The examination of 120 species of Brachiopoda, distributed through the entire series of palaeozoic strata, from the lower Silurian up to the present epoch, has enabled the author to observe, without a single exception, the spectrum of strontian, the quantity being, however, always less than 1 centigram.

Reasons of an exclusively geological character led M. Dieulafait to affirm that the gypsums of all strata have for exclusive origin the evaporation of sea water at the ordinary temperature of the epochs of their formation. If this be the case, all the gypsums, whatever their age, should contain strontian. He examined 183 specimens of gypsum obtained from the region of the Alps and of the South-east of France, gypsums belonging to the trias; 55 specimens of gypsums of tertiary formation; 4 specimens of gypsum with mica (metamorphic gypsum); 6 specimens of ophitic deposits from the Pyrenees. All, without exception, gave the characteristic spectrum of strontian with a few milligrams of substance.

A detailed examination of layers of gypsum from the same deposit—layers which in certain cases rose to 120—proved that the strontian was disseminated throughout the mass of gypsums, and did not constitute small accidental deposits.

All the saliferous mineral waters, hot or cold, borrow the greater part, and in many cases the whole, of their mineral principles from the saline substances existing in sedimentary strata—substances arising from the spontaneous evaporation of the waters of ancient seas. As all these saline deposits contain strontian, all these saliferous waters should contain strontian. The *Dictionnaire des Eaux Minérales* mentions 840 springs coming under the definition of saliferous waters; of these 800 there are only 44 in which strontian has not been met with. The author has searched for it in 71 other springs taken quite at random. In all, the presence of strontian was observed, the quantities of water operated with not exceeding 100 c.c.—*Comptes Rendus*, 1870.

SUBERINE. A peculiar substance possessing an organised structure, which is much used by calico printers as a thickener for colours.

SUGAR. (Vol. iii. p. 925.) The following remarks on sugar show so clearly the present condition of the sugar cultivation and manufacture that they have been transferred from the *Saturday Review*, in which they appeared, to our pages:—

'The sudden rise in the price of sugar which has occurred during the past two months (November 1876) is for many reasons not unnaturally attracting attention beyond the limits of the purely commercial classes. Comparing the wholesale prices of the present time with those of twelve months ago, we find an advance of from 30 to 40 per cent.—let us say, roughly, of one-third. Even at that rate the poor needlewoman and the wife of the common day-labourer would have to pay 6*d*. per lb. for the sugar which cost them only 4½*d*. a year since. But we need hardly tell our readers that, if the rise in the wholesale price is maintained, it will entail a more than proportionate rise in the retail price. For the retailer must have his profit on the additional outlay as well as on the old cost, and he will take care, we may be sure, that that profit is not too meagre. But a rise of 1½*d*. or 2*d*. per lb. in an article of universal consumption, as sugar has now become, would be a serious matter to the struggling poor at the beginning of winter, in a period of depressed trade, and while apprehensions of war on the vastest scale are discouraging all investment. It may be that the rise which has taken place is not justified. Indeed, recently there was a downward tendency in the markets, which, however, has been checked.'

After noticing the condition of the sugar trade during the war with France, the writer proceeds:—

'In consequence, the price of sugar and other articles of the same kind almost reached famine rates. NAPOLEON set about remedying the injury, and the cultivation of beet-root as a source of sugar was encouraged in every method by his Government. The fall of NAPOLEON and the consequent opening up of the whole continent to British trade retarded the growth of the new industry. Still NAPOLEON's policy was pursued by the Government that succeeded him. Among other modes of protection, beet-root sugar was exempted from all taxation, while a heavy duty was imposed upon foreign sugar. By this means the indigenous manufacture was fostered; and consequently we find that in 1832 about 9,000 tons of sugar were manufactured in France, which was about one-seventh of the total consumption of the country. After this period a new cause came into play, which gave an extraordinary impetus to the beet-root industry. The long agitation against slavery in this country triumphed, and negro emancipation was accomplished in the West Indies. The first results, as our readers are aware, was the disorganisation of the West Indian labour market. And France took advantage so promptly of the opportunity that in 1842 her production of indigenous sugar had risen to 35,000 tons. It was an almost fourfold increase in ten years, and was very nearly one-third of the whole consumption, instead of one-seventh, as it had been in 1832. From this time the industry prospered so rapidly that a duty, less indeed than that on foreign sugar, but still of appreciable amount, was imposed on the beet-root product; and in 1847 that duty was made equal to the foreign duty. Still the industry attained greater proportions. In 1862 the home production somewhat exceeded the foreign imports. And in 1871 it was four times greater. Since then the home production has still further increased, until the foreign imports, compared with it, are but a small fraction. Last year (1875), in fact, the home production exceeded 440,000 tons, nearly twice the amount of 1871. During 1874 and 1875 the wholesale price of sugar at Paris averaged 140 francs per 100 kilograms. At that rate the home production last year amounted in value to over 25,000,000*l.* sterling. Thus in less than seventy years an industry has been created which is worth this enormous annual sum to France. In the meantime Germany, Austria, Russia, and Belgium followed the example of France. And the total production of beet-root sugar in Europe is now estimated considerably to exceed 1,000,000 tons.

'In 1860, when Mr. LOWE first proposed the reduction of the sugar duties, he grounded his proposal on the fact that sugar, even then, was the solace of all classes and both sexes from the earliest infancy to tottering old age. And the quick reduction and final repeal of the duties have stimulated still further the universal consumption. Between 1860 and 1875, in fact, the consumption per head of the population in the United Kingdom has increased from 42 lb. to 62 lb. per annum; that is to say, the consumption is now nearly 1¼ lb. per week, and the value of the sugar imported last year exceeded 21,500,000*l.*

'The importance of the sugar crop of France, not to herself only, but also to us, will now be apparent. And as to its importance to us we need only add to what we have already said, that last year (1875) the sugar we imported was equal in value to two-thirds of the wheat we imported, so universal an article of consumption has it now become. But the French crop this year (1876) is said to have failed. It is impossible thus early to judge how much exaggeration there may be in the reports of failure. It is commonly alleged that the out-turn will not exceed 250,000 tons, against 440,000 tons last year; but the truth will probably not be so bad. However, there is no doubt that the crop is a very short one. It is also said that the crops in other European countries are deficient, although we have seen the statement contradicted. And, lastly, the sugar-cane crop in the United States appears to be short. The cultivation in the United States has been decreasing ever since the Civil War. The crop is therefore of no very great importance. But the American consumption at the same time has been rapidly increasing, and this year the demand has been abnormally great. The American purchases in our market are indeed among the causes of the present perturbation. The result of this combination of adverse circumstances is that the wholesale prices have risen within the last two months from 20 to 30 per cent. It is quite possible that a large part of the rise may be due to speculation, and that the failure is not so great as to justify so extraordinary an advance. But it is also possible that even a greater rise may take place and be maintained. Even at the present level, if we import the same quantity as last year, our supply will cost us 5,000,000*l.* more. Of course it may be that the enhanced price will check consumption. If it does not, it will diminish the sum which the lower section of the working classes will have to lay out on other articles. In any case, it will be felt by them in a diminution of comforts. As for France, the failure cannot but tell heavily on the peasantry, coming, too, at a time when the *phylloxera* is committing such ravages, it will be doubly trying

to the country. And it will seriously affect the revenue, the duty upon sugar contributing a very considerable amount. The duty was increased in three successive years since the war; and it is a curious circumstance, which deserves to be noted here as completing our historical sketch of the beet-root industry, and showing once more in what unexpected ways legislation affects trade, that these increases of taxation actually stimulated the cultivation of beet-root. On exportation a drawback is allowed, and this drawback is so calculated that the exporter gets more than the duty he had paid. The drawback is thus in reality a premium on exportation, and as such it has acted, stimulating so greatly the exportation to this country that our own refiners and the colonial growers complain that they are being ruined.'

It now becomes necessary to give an official statement of the condition of our sugar manufactures and of the consumption of sugar in the United Kingdom for the last three years.

Mr. Henry Chamberlain, in his paper read before the British Association at Bristol in 1875, gives the following particulars:—

Barbadoes first exported sugar to England in 1646.

The West India trade continued the principal one until 1844; then free labour of other places was admitted.

From 1844 all kinds of sugar were imported free, and slave labour and the *duty was entirely abolished in* 1874.

In 1832, the year before slave emancipation, the total import trade with Bristol was 31,229 tons.

In 1843, the year before the admission of free labour, it was only 16,611 tons. From that time it gradually increased to the following quantities:—

In 1872	94,528 tons
„ 1874	81,914 „
„ 1875	91,921 „

According to Mr. Henry Chamberlain, the entire import of sugar into England in 1700 was only 10,000 tons. In 1874 the total consumption of sugar exceeded 700,000 tons, and in 1875 the consumption rose to 964,477 tons. The total consumption of sugar in the United Kingdom in 1874 was 719,343 tons.

	Cwt.	Value
In 1875 the imports of sugar refined, or sugar equal in quality thereto, and sugar candy was	2,660,776	£4,338,166
Unrefined of all kinds	16,264,711	17,210,137
Glucose, solid or liquid	237,297	239,085
Molasses	708,410	420,449

Manufacture of the United Kingdom exported in 1875.

	Cwt.	Value
Refined and candy	972,263	£1,149,379
Molasses, treacle, and syrup	162.983	127,519

Colonial produce being—

	Cwt.	Value
Refined and candy	266,124	£391,317
Unrefined of all kinds	484,820	578,558
Glucose	4,425	4,281
Molasses	86,982	62,211

Reserved for home consumption in 1875, 964.477 tons.

In 1876 our imports were:—

	Cwt.	Value
Refined sugar and candy	2,796,414	£4,118,166
Unrefined of all kinds	15,612.214	16,333,811
Glucose, solid or liquid	221,485	212,323
Molasses	498,441	234,009

Manufacture of the United Kingdom exported in 1876.

	Cwt.	Value
Refined sugar and candy	1,192,277	£1,363,908
Molasses, treacle, and syrup	231,027	155,068

Our exports of colonial produce in 1876 being 1,059,342 cwt.

In 1877 our imports were—

	Cwt.	Value
Refined sugar and candy	3,429,823	£5,793,614
Unrefined of all kinds	16,633,438	21,343,158
Molasses	206,357	140,570

Manufacture of United Kingdom exported.—Refined sugar and candy, 1,119,543 cwt. Foreign and colonial produce exported, 671,301 cwt.

The detailed statement of our importations of sugar in 1874, 1875, and 1876 is given for the purpose of showing the variations of the imports from the several countries within that period:—

Refined Sugar, or equal in Quality thereto, and Sugar Candy.

	1874		1875		1876	
	Cwt.	£	Cwt.	£	Cwt.	£
From Russia	—	—	—	—	10,632	23,560
„ Germany	9,192	13,156	7,867	13,169	30,976	48,862
„ Holland	561,817	809,064	630,417	790,600	647,008	920,865
„ Belgium	128,337	124,388	119,596	161,349	68,508	107,417
„ France	1,834,609	2,816,374	1,520,114	2,318,634	1,772,112	2,608,234
„ Egypt	110,403	150,734	3,472	4,551	8,940	11,940
„ Java	11,673	13,610	—	—	—	—
„ United States of America	—	—	240,079	368,581	230,266	341,812
„ Spanish West Indies .	15,632	23,120	—	—	—	—
„ French „ .	42,342	57,630	40,442	55,679	39,096	56,411
„ other Countries . .	861	1,451	1,029	1,244	218	324
Total	2,717,400	4,173,112	2,560,779	4,328,360	2,790,414	4,119,166

Unrefined of all Kinds.

	1874 Cwt.	1874 £	1875 Cwt.	1875 £	1876 Cwt.	1876 £
From Germany	382,049	406,703	568,209	583,644	1,514,233	1,668,760
„ Holland	74,998	83,797	60,692	72,423	290,440	316,700
„ Belgium	791,765	902,852	501,100	550,244	679,921	691,345
„ France	1,048,017	1,206,224	1,016,148	1,146,930	698,203	707,929
„ Portugal and Azores .	34,611	40,456	—	—	—	—
„ Italy	—	—	14,940	22,500	—	—
„ Egypt	242,016	343,754	146,914	180,867	230,453	304,290
„ Bourbon (Réunion) . .	23,606	28,509	—	—	—	—
„ Java	984,850	1,200,610	1,191,000	1,436,918	1,218,600	1,400,061
„ Philippine Islands . .	769,040	687,035	636,869	766,152	1,097,346	901,006
„ China	—	—	—	—	260,607	254,002
„ Spanish West Indies .	2,197,801	3,081,030	2,033,141	2,616,416	1,640,515	1,700,122
„ French „ . .	68,323	88,349	63,000	79,200	80,214	91,087
„ Dutch Guiana . . .	88,862	117,349	86,325	106,825	61,385	82,734
„ Central America . .	40,013	47,337	—	—	—	—
„ New Granada . . .	10,121	10,374	61,237	80,106	31,773	31,567
„ Peru	472,763	612,112	808,393	939,763	900,146	912,790
„ Chili	—	—	20,077	21,256	19,590	20,672
„ Brazil	1,749,870	1,749,342	2,343,640	2,506,889	1,279,462	1,229,362
„ British Possessions in South Africa . .	17,130	17,392	39,376	29,540	85,702	88,273
„ Mauritius	706,042	683,805	245,355	611,227	710,735	590,964
„ British India:						
„ Bombay and Scinde .	609	877	—	—	—	—
„ Madras	127,160	129,217	279,437	281,617	348,683	334,714
„ Bengal and Burmah .	118,846	123,200	41,335	47,507	110,306	118,679
„ Straits Settlements . .	92,240	80,052	110,694	98,564	101,319	88,762
„ Australia (Victoria) .	55,467	44,150	—	—	—	—
„ British West India Islands	2,628,305	2,734,544	3,522,430	3,700,268	3,607,413	3,615,240
„ „ Guiana . . .	1,109,899	1,294,041	1,210,193	1,433,891	1,562,822	1,920,769
„ „ Honduras . .	22,613	21,862	84,616	72,393	36,594	33,074
„ other Countries . .	31,487	27,664	46,157	45,002	109,434	116,657
Total	14,190,941	15,837,617	16,304,711	17,310,137	15,612,214	16,330,911

SUGAR MANUFACTURE. (See vol. iii, p. 925; CONCENTRATION VACUUM PAN, p. 945.) In the description referred to HOWARD's vacuum pan is especially described, condensation by injection being the practice followed.

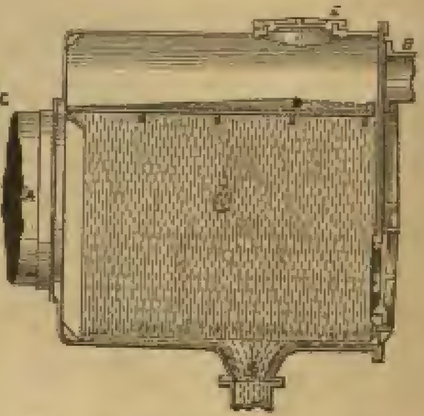
The so-called 'excelsior vacuum pan condenser' professes to effect a vast saving in the consumption of condensing water. This pan is the design of the firm of Messrs. BLAKE, BARCLAY, and COMPANY, engineers, of Greenock. The woodcuts give first a sectional elevation, second a cross section, third a plan, and fourth a back end view.

The following is a description in detail:—The apparatus consists essentially of a large cast-iron tank of oblong construction, measuring 6½ to 7 feet in length, 4½ to

4½ feet in width, and 6½ feet in depth, having a gross capacity of 200 cubic feet, and a condensing space of 145 to 150 cubic feet. Its sides and ends are vertical, its top or roof flat-arched, and its bottom curved, as in the letter U. It is set longitudinally, mounted on a wooden or cast-iron gawntree, like a liquor cask in a wine-cellar, and when looked at endwise has very much the resemblance of the letter U, surmounted by a semi-circumflex, thus ($\bar{U}$). The tank is in one piece, with the exception of the back end, which admits of being detached from, and readjusted on, its seat when removing and replacing the internal grating-plate, which is inserted and removed from the back end. The grating-plate (which is usually of copper) occupies an elevation on a line with the base of the arch or roof, and is fixed in position by being fastened down with brass screw-bolts and nuts to a series of little brass (or cast-iron) cross-bars (similar in shape to ordinary furnace bars) stretching across the condenser at proper intervals; as likewise to the projecting flange at the base of the arch or roof, and also to an inside flange or 'listing' cast on to the front end of the condenser. It is made to fit closely all round the tank, save at the back end, between which and the grating-plate an open space of about 2½ inches intervenes for direct communication between the upper and lower compartments. This intervening space is virtually the only medium of direct communication between the air-pump on the one hand and the vacuum pan on the other—the neck pipe, A (*figs.* 2544 and 2545), the condenser itself, and the vacuum or air-pump pipe, B, being the connecting media.

2543

2544

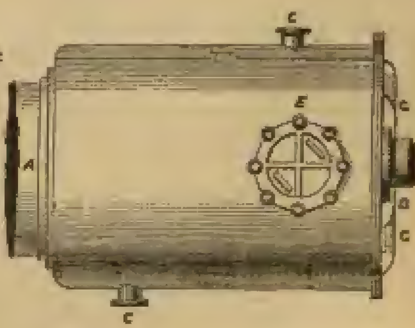


The grating-plate is for the uniform spread or distribution of the condensing water in the form of a rain-shower in the lower compartment of the condenser, and, with this view, is perforated with innumerable small holes, and is turned up at the back end to the depth of about 2 inches, so as to retain a constant head of water over its upper surface. The condensing water is injected on to the upper surface of the grating-plate by the two side-pipes, C (*figs.* 2542 and 2545), near the top of the condenser, the injection being regulated by means of stop-cocks on the pan-room floor; the discharge being effected by the converging or hopper-shaped branch, D, at the bottom, from which the gravitation-pipe is depended, which, as is well known, works on the principle of the water-hammer. A narrow, obliquely-set copper plate, pointing inwards and downwards, extends across the front of the condenser in the interior, which is termed the splash-plate; for by means of it the front jets of the water-shower are thrown inwards, so preventing the water splashing down the neck-pipe, A, into the vacuum pan below. It is secured in position along with the fore end of the grating-plate to the flange. Inserted on either side the condenser, towards the centre, is a little plate-glass window, looking through one of which, and the other acting as a reflector (a light burning alongside), the action of the water-shower in the interior may be seen from the outside. At E (*fig.* 2545) is a manhole in the roof of the condenser for admission to the upper compartment to bolt or unbolt the grating-plate, as also to joint or disjoint the upper portion of the neck-pipe, A, in front. At F (*fig.* 2543) is a manhole in the lower portion of the back end for admission to the lower compartment, to fasten or unscrew the bolt-nuts of the grating-plate, and to joint or disjoint the lower portion of the neck-pipe, A, before mentioned; and at C are

two brass-mounted handholes in the back end—one on either side the vacuum pipe, B—for access to joint or disjoint the branch, B, communicating with the air-pump, as also for the purpose of inserting a long-handled broom or mop into the upper chamber to clear the upper surface of the grating-plate of glutty matter, &c., which may have entered with the condensing water. The back end, as we before remarked, admits of being detached bodily from the rest of the condenser and rejointed, in the event of requiring to remove the internal grating-plate, in which event, of course, the vacuum-pipe branch, B, is also necessarily detached from its seat and rejointed as before. The action of the condenser is simply as follows:—The vacuum pan being in action, the vapour disengaged from the boiling syrup therein is withdrawn into the condenser by the exhausting air-pump, entering the lower compartment by the neck-pipe, A, in front. The vapour, on its entering the condenser, is caught up through the midst of the water-shower against the under surface of the grating-plate, and is thus brought into direct and most intimate contact with the condensing water in the shower, parting the while with the greater portion of its heat, which is communicated to the water; the vapour interblending with the water in the course of the process, and falling with it more or less condensed. Any vapour escaping due condensation meanwhile, as also that given off by the condensing water itself, ascends up through the water-shower in the same manner, and falls with it as before; the water used in, and that also produced by the condensation, becoming the while interblended, and in course

2545

2546



passing off together by the branch, D, at the bottom of the condenser into the gravitation discharge-pipe before mentioned; and so on continuously during the space of the boiling operation. As the boiling is continued and the process of condensation goes on, cold water is being constantly injected (more or less) into the condenser by the pipes, C, so keeping the grating-plate well covered, and insuring constancy and regularity in the shower.

In this condenser the water abstracts from the vapour and carries off a larger portion of heat than in the ordinary condensers. Throughout the process the condenser itself is kept cool, as is also the exhaust-pipe leading to the air-pump, and hence the vacuum is more perfectly secured.

The vapour from the vacuum pan enters the condenser at an average mean temperature of 130° Fahr., and the condensing water at from 55° to 62° Fahr., while the discharge water leaves the condenser or the reduction pipe at an average mean temperature of 90° to 95° Fahr.

Many pans at work in Greenock, furnished with the ordinary cylindrical condenser and boiling from 12 to 15 tons at a charge, consume not less than 630 imperial gallons of condensing water a minute, while in the case of pans furnished with the 'Excelsior' condenser, and boiling 28 tons of sugar at a charge, the average water consumption does not exceed 230 imperial gallons per minute.

Insufflation of Air for Evaporation of Syrup.—By a communication from M. Ed. Moride, of Nantes, published in a recent number of *Les Mondes*, the following account of experiments in evaporation by the injection of air is given. An apparatus constructed by MM. La Pommeray and Pinel has been placed at the saltworks of

Croisic, belonging to MM. Ernott. It has worked with great advantage, producing much economy in time and a saving of nearly 40 per cent. At the Etienne sugar refinery the method has been applied in the working of beet-root juice to the weak liquor of 5°, as well as to the syrup of 25° density, without alteration of the juice or change of colour. Both the raw juice and the syrup have been concentrated nearly to 42° density by a temperature of 80° to 86° C. (176° to 187° Fahr.), and have crystallised perfectly without any greater production of glucose than accompanies other methods of working. The evaporation progresses at the rate of an increase of density of 5° per hour, between 6° to 25°, when it is accelerated to the rate of 6°, 7°, 8°, and 11° of concentration per hour. At the A. Cesar refinery the apparatus for insufflation of air has been applied to a vacuum pan, and works perfectly, only that the vacuum cannot be maintained constantly except at 45° C. (113° Fahr.); otherwise, by admitting less air the vacuum can be raised, but the temperature will then be increased, to the detriment of the formation of a regular grain. The sum of the results of the experiments in sugar-making is—(1.) That the insufflation of air augments considerably the evaporation of liquids. (2.) That this method procures an economy of fuel of nearly 40 per cent., together with much saving of time, so great as to permit an ordinary boiler of evaporation to accomplish five times the usual results. (3.) That the insufflation is without injurious action upon the sugar solutions; that it neither affects the colour nor inverts the crystallisable sugar. It is demonstrated to be possible then, with all security, to apply this novel method of evaporation to sugar-juice nearly to 35° or 40° of density; but the determination of the boiling may be effected in a vacuum pan, as is ordinarily done, or may be effected in free air. Commenting upon this note, the *Journal of the Franklin Institute* observes the method of insufflation and evaporation referred to is simply the blowing of streams of air, not necessarily heated, into a liquid warmed by some usual means to some desired temperature, which may or may not be the boiling point of the liquid. The active circulation promoted by the levity of the air-bubbles and the extended surface which is given for the evaporation of vapour to take place from, is supposed greatly to increase the efficiency of the heating surface to dispense heat to the liquid, by increasing the difference of temperature of the liquid where it comes in contact with the heated surface. The claim of saving of fuel—that is, of effecting a greater evaporation by the same quantity of heat—would seem to need more positive evidence, for the admission involves the establishment of new laws in physics, but the possibility of accelerating the process of evaporation by the method can be readily conceived and admitted in moderate degree; certainly, however, not that the same heating surface could be made practically efficient for five times the usual results.

SUGAR-CANE, 'RUST' IN. Professor Liversidge, of the University of Sydney, has drawn attention to a disease of the sugar-cane which has appeared in Queensland, and which is known in many other sugar-cane producing districts. From Professor Liversidge's report the following particulars are abstracted.

The Character of the Disease.—Some of the actual statements made by sugar-cane growers will best describe the disease:—

'We first noticed the cane disease in 1871; during the previous year a large quantity of rain had fallen, and the district had suffered severely from floods. Bourbon cane was the first affected, and grew on the block from a sandy soil. After a few months we cut and burnt it. The cane had been cut about the end of 1870, and when 3 feet high trenches were opened in alternate rows with hoes, and the trash buried. In twelve months' time most of the Bourbon cane on Jindah was affected, and some blocks seriously injured. The disease has since then continued to spread rapidly. Three years after the stumping and cross-ploughing, &c., the block on which the disease first appeared was planted with Rappoe cane; this grew well, and was cut when two years old, but the disease again appeared, and chiefly in the sandy part before mentioned. The ratoons, now one year old, show the disease worst in the same place.'

Again, the same writer says, in reference to another question:—'The disease generally appeared when the cane was 3 or 4 feet high, about the beginning of the year, when the rains were commencing; it spread rapidly until the cold weather was felt, and then but slowly; when the spring came many of the canes would recover their strength and become fit for crushing. This year, however, it has been much more severe, and the cold weather did not check it; only a few isolated canes are growing, and these are unfit for sugar. This has been a very wet season, but we think that the disease has gained ground more rapidly every year since it first appeared.'

Another sugar-cane grower says:—'In March last I first observed several small red-looking spots in a cane piece on the scrub soil; on examination I found the soil of the part affected to be an old bed of a scrub turkey's nest, the soil being 2 or 3 feet deep with decomposed leaves; the number of spots increased daily, till in two weeks

several acres in the centre of the piece had died out. The disease now showed itself all round the estate; every day on the highest and driest soil it could be observed working downwards to the valleys, and by the end of April it had affected every stool of the Bourbon variety on the estate. The cane on the forest soil was affected but slightly, as it has quite recovered.'

After describing all the conditions of the cultivation of the cane, Prof. LIVERSIDGE proceeds to give his examination of the diseased canes:—

'I may mention that my attention was first drawn to this disease in June last. I subjected to a patient and searching microscopical examination the canes submitted to me, but failed to detect anything which could for a moment be considered as the cause of the disease. The diseased canes were, it is true, affected by minute fungoid growths, but these were not a sufficient cause for the diseased appearance of the plant—the presence of the fungoid growths would be accounted for by the general weakness and sickliness of the cane.

'The fungi were, undoubtedly, the consequence of, and not the cause of the disease. These fungoid growths, although not the cause of the disease, are apparently intimately connected with the red marks on the leaves, known as the 'rust,' and they are found both on the affected and on what are considered healthy canes, although to a much smaller extent on the latter.

'These red spots or rust marks do not all appear at once, but gradually; in the first instance, the leaves of the affected cane are seen to be covered with a multitude of small light-coloured spots. These spots are much more transparent than the other portion of the leaf, and are best seen by holding the leaf up to the light. They are probably caused by the decay, or non-secretion of the green colouring matter—chlorophyll; but, in addition to these, red-brown spots gradually make their appearance, and increase in numbers until the colour of the leaf is completely changed. The leaves meanwhile droop, become dry, brittle, and finally fall off when touched. In other words, they wither away and die, the growth of the cane is of course arrested, and sooner or later, unless a change takes place, it dies likewise.

'On stripping off a leaf from the cane there is usually to be seen under the leaf-scroll, and near to the bud, a patch of dark-red, brown, or purple matter; this, on close examination with the aid of a lens or microscope, is seen to be resolved into a number of minute, more or less cup-like bodies, each with an irregular rim or opening; the opening or mouth is often partially closed by flaps, and then it is usually roughly triangular in form. These little cups are connected together by dark-red and purple filaments, which spread over the surface and penetrate into the substance of the leaf; many are seen to pass completely through its substance by the presence of corresponding red or rusty-brown spots on the opposite surface. Some of the filaments appear to bear spores.

'These fungoid growths bear a very strong resemblance to a large group of very common microscopic fungi, known as the *Æcidiacei*, and they probably belong to that order.

'Near to the dark-coloured cup-like growths are seen others of a lighter colour; and again, a little further beyond, are very light and perfectly colourless bodies, quite spherical in shape, and filled with fluid; these minute spheres are apparently the æcidiacei in an early stage, which as they mature become darker in colour; and finally, when ripe, burst at the top with an irregular rent, and form the cup-like bodies already noticed. After they have burst and discharged their contents they present somewhat the appearance of an empty currant skin; the internal surface is of a much lighter tint than the external.

'On that portion of the leaf which is opposite to, and comes in contact with them, a brown stain is seen; and it follows that, as the leaf develops and pushes up past the fungi, different parts of the leaf must successively come into contact with them, and thus the whole of any particular leaf of a weak and sickly plant unable to resist their attacks becomes, as it were, inoculated with the spores, which develop and thrive at the expense of the leaf-tissue, which is destroyed wherever attacked, as indicated by the red-brown rust spots. This is offered as one explanation out of several possible ones, to account for the presence and general diffusion of the rust spots, but not as an explanation of the diseased condition of the cane itself, the cause of which, as already mentioned, exists elsewhere.

'The rust spots on the leaves are often seen to have split open and to have extruded a minute quantity of a white powdery substance; a similar white powder is also scattered over the surface of the diseased leaf, and the same thing is seen on the healthy leaf, but in much smaller proportion; this powder is probably of the same nature as the white deposit, generally seen at the joints of the cane. As might be expected, the leaf-cells under the rust patches are seen to be more or less destroyed

and to contain a brown-coloured decomposed matter, and through it fungoid filaments (mycelium) are seen to permeate.

'The roots of the diseased cane are by some said to be covered with mildew, but, as far as I could observe, this does not appear to be the case until the cane is utterly destroyed, and undergoing actual decomposition. I, however, noticed that the rootlets are covered with minute white, or nearly white, hairs, which at first sight have much the appearance of mildew.

'Feeding upon the æcidiacei numerous minute acari were seen, white in colour and almost transparent. Along with them were beautifully symmetrical, equally transparent oviform bodies, which are probably the acari in an undeveloped stage.'

Professor LIVERSIDGE then proceeds to give his analysis of healthy and diseased canes. The following is an analysis of the ash of a diseased Bourbon cane:—

Silica	34·51
Soluble silica	·39
Alumina	·87
Manganese protoxide	3·79
Lime	5·99
Magnesia	2·67
Potash	10·84
Soda	17·28
Sodium chloride	6·50
Phosphoric acid	5·78
Sulphuric acid	9·87
Non-estimated constituents	1·51
	100·00

He then gives the analyses of a diseased and a healthy rappoe:—

	Diseased Rappoe	Healthy Rappoe
Silica	13·60	50·47
Peroxide of iron	1·30	minute traces
Alumina	not estimated	·68
Manganese protoxide	traces	·36
Lime	4·57	3·64
Magnesia	3·12	·20
Potash	16·55	7·61
Soda	29·78	17·76
Sodium chloride	9·38	9·27
Phosphoric acid	5·86	9·44
Sulphuric acid	12·82	traces
Non-estimated constituents	2·93	·57
	100·00	100·00

The following are analyses of the ash of diseased troobœ, very green in colour and somewhat deliquescent; and of the ash of healthy troobœ, of a deep bluish green colour, and very deliquescent:—

	No. 1. Diseased Troobœ	No. 2. Healthy Troobœ
Silica	11·36	22·82
Alumina	not estimated	not estimated
Manganese protoxide	,,	7·63
Lime	8·08	4·62
Magnesia	1·22	·82
Potash	19·76	15·06
Soda	35·20	25·44
Sodium chloride	4·50	5·16
Phosphoric acid	10·27	7·34
Sulphuric acid	4·90	7·08
Non-estimated constituents	4·71	4·04
	100·00	100·00

Analyses of the soil on which both the diseased and the healthy sugar canes had

grown were made without discovering any marked peculiarity. After exhaustively examining the results obtained, Professor LIVERSIDGE comes to the following conclusion:—

'When the crop is an exhaustive one, the restitution may either be made by the addition of artificial manures, or the restoration may be allowed to take place naturally, by the slow and tedious process of fallowing. The two processes are not, of course, quite similar, but much the same result is obtained. When land is allowed to lie fallow, sufficient time is allowed for fresh portions of soil to pass into the state into which they can be taken up by the crop grown. This is mainly the result of the slow disintegration and decomposition of new portions of soil. Fresh portions of soluble matter thus replace those which have been abstracted.

'But a crop like the sugar-cane cannot well be termed exhaustive, since the sugar, which is really the only thing which should be entirely removed from the land, consists in a pure state of nothing but carbon, hydrogen, and oxygen, and thus it differs greatly from tobacco and other similar crops, rich in inorganic substances, which are almost wholly utilised, and are removed, not only from the land, but also from the district. It is, however, true that a certain small proportion of inorganic matter or ash does go away with the sugar, for commercial sugar is not a chemically pure product; but the main bulk of the salts or inorganic matter taken up by the cane from the soil, together with all the cellulose, starch, albumen, and other organic compounds, remain in the waste products. Therefore, if the waste products be returned to the soil, the amount of matter of all kinds permanently removed from the land would be very small indeed, and the land could be cropped year after year, with but little drain upon it, and the slight annual loss could be met by the use of a small amount of manure to supply the deficiency.

'This deficiency will consist partly of organic and partly of inorganic matter. The amount of organic matter removed would be much greater than it is were not much of it derived by the cane from the carbonic acid existing in the atmosphere. Practically, it is found, where the soil is fairly good, that the waste products, supplemented by the ploughing in of an occasional green crop, afford quite sufficient organic matter.

'I purposely repeat, for I cannot impress this matter too strongly, that all the waste products obtained during the manufacture of the sugar must imperatively be returned to the land.

'The megass, which should be returned to the land in the green state, and on no account used as fuel, the scum, the dunder, and the refuse washing waters ought all to be restored to the soil, and even the molasses, unless they can be disposed of at so profitable a rate that other equally good manures can be obtained to replace them.

'All of these substances contain the actual salts and organic matter in the proportions required by the cane, and they are accordingly of the utmost value and importance to its proper growth. The organic matter will for the most part have to decay before it can be assimilated, but then the products of decomposition will exist in the proper proportions.

'The megass, together with the trash, should be ploughed into the land in the green state, in order that the whole of it may be utilised; and as it decays it will tend to leave the soil open and porous. The water which enters into its composition will not only hasten its decay, but will also serve as a reservoir of moisture, which is slowly given out, and will in dry weather become of great benefit to the growing crop. I found in the course of conversation that some of the planters were inclined to attach but little importance to the use of megass as a manure, because much of the woody fibre was found to remain undecomposed after lying in the ground for a year or so; but then this was megass which had been stacked for some time, and which had consequently lost much of its soluble matter, and also a very large proportion of that which was fermentable. In fact, such megass consists mainly of matter which has resisted decomposition; the matter forming the stack owes its very existence at that period to its power of resisting decomposition—all the readily decomposable and therefore most valuable part had either drained away or been volatilised. The rich dark-coloured stream of liquid seen draining from every fresh megass heap is proof that green or new megass does contain a large quantity of organic and inorganic matter which cannot possibly be present in the old megass. From old megass I should certainly expect that but little benefit would be derived until after it had been in the ground for a year, or even two or three years. But by using the megass in its fresh state, an improvement would, I think, be apparent during the first year, and as the less readily decomposable portions underwent gradual decomposition, they would slowly become available as plant food; but it would probably be two or three years before the megass was completely used up. It is by no means a new thing to plough in the fresh megass. It was practised by WRAY, the well-known writer upon the

cultivation of the sugar-cane, and others, with great success, many years ago in the West Indies.

'If, from circumstances which may exist, the green megass tends to render the soil sour, the acidity may be counteracted by ploughing in a small proportion of lime with it, but under ordinary circumstances there will be no occasion to do this.

'It is a very bad plan to stack the megass, or any manure, into heaps, since the richest part drains away; all the unexpressed sugar is thus lost, and moreover, there is a great loss from the evaporation of the volatile constituents; the greater portion of the ammoniacal salts are thus volatilised, plainly indicated by the smell of a manure heap. And further, too often the manure oxidises by such exposure, and becomes rank and unwholesome to the plant.

'The molasses contain nearly all the soluble salts which exist in the cane juice, and when the molasses are fermented and distilled, these salts remain in the dunder. The dunder contains a large proportion also of organic matter; one sample which I brought away with me was very rich, and in addition to the organic portion there was present a large percentage of salts, consisting principally of salts of lime and potash, together with phosphoric acid, all of the greatest value as inorganic food to the cane plant, and yet over 600,000 gallons of it are annually thrown away. The money value of the manure thus sent out to sea would be found to amount to no mean sum.

'To make up for the loss which the land has undergone, I would recommend that the following manure be applied at the rate of from 4 to 5 cwt. per acre:—

Bone meal	35 parts	All in fine powder.
Superphosphate of lime	25 "	
Sulphate of lime	25 "	
Nitrate of ammonium	15 "	

'Should nitrate of ammonium not be readily obtainable, nitrate of potassium may be substituted. Manures, however, containing potash, soda, and magnesia, should, as a rule, be avoided for the sugar cane.

SACCHAROSE ESTIMATION.—The accompanying table, giving the results obtained by SCHEIBLER's process upon Colonial sugars, by LOTMANN, may be of interest to those chemists who have not had the opportunity for giving that process a fair trial. Mr. ROBERT FRASER SMITH, of Glasgow, who communicated the paper from which it is taken to the *Chemical News*, writes:—

'Owing to the results being uniformly higher than those found by the French method, it probably has no chance of being adopted by the buyers of raw sugars or those acting for them; but in the private laboratories of refineries the information which such a determination of the actual quantity of saccharose present in any sample gives may induce some chemists to procure the apparatus. The table will show that it is absolutely indispensable to dry all samples containing more than 2 per cent. of moisture previous to treatment, in which case the ether will be unnecessary. Upon sugars containing much caramel or other colouring matter, an alcoholic 3 per cent. hydrochloric acid solution will be found to answer better than the acetic, giving at the end a perfectly white product.

'With regard to the "amorphous sugar," it might be well to wait for more light before accepting the existence of such a body. The sugar obtained by precipitating with alcohol from a sample of molasses which has stood for a year without any signs of crystallisation presents the appearance of an impalpable powder, and from its state of minute division is slightly more soluble in alcohol than the crystalline cane-sugar of commerce, containing 99·8 per cent. of saccharose, but on solution in water and evaporation it crystallises in the ordinary form. Crystalline salts dissolved in gum or gelatine behave in exactly the same manner, but no one has yet talked of amorphous common salt or nitre. Molasses containing, on dried product—

Saccharose	75·50
Glucose	0·41
Ash	11·31
Organic matter	12·78
	100·00

which a friend kindly sent me from Paris, and said to be derived from the residues of the "sucrate of the hydro-carbonate of lime process," on being diluted to 30° B. and exposed to a freezing mixture to get rid of excess of salts and saccharose, the mother liquid treated with alcoholic ether (being first concentrated), yields a large crop of what I understand to be the so-called amorphous sugar. But a glass of small power

shows distinct crystalline faces, and it yields to water and evaporation the usual result. I humbly think that the amount of crystallised sugar got from any solution of saccharine matter will be found to depend, other things being equal, upon the value which pertains to the figure denoting the coefficient of viscosity. Some salts, such as the magnesian, instead of hindering, promote sugar crystallisation. In short, the salts which take longest when in solution to transpire through capillary tubes are those which hinder crystallisation most. Hence the alkaline organic salts are the great molasses formers, and hence also the benefit derived from MARGUERITE's process in the beet *fabriques*, which adds sufficient hydrochloric acid to transform these into chlorides, the other acids being sent off in the boiling.

'The rate at which any syrup travels through a capillary tube (a solution of pure sugar being 100) will express the crystallising capabilities of the sugar contained in it; due regard being had to temperature, pressure, strength, &c., being alike in the various trials. Mr. HUMPHREY mentions cases in which glucose is present in an optically inactive condition; but so far as I know this never occurs in cane sugars, but it is so abundantly in date sugar, and also the sugar from many fruits.'—*Chemical News*, June 2, 1876.

Table of the Refining Values (Raffinations Werthes) of Different Raw Sugars.

Name of the Sugar used	100 Parts of the Raw Sugar contain—								Remarks
	Crystallisable Sugar	Glucose	Ash	Water	Organic and Insoluble Matters	Nett Sugar (Ash × 5, Glucose × 1)	Refine Value. Rendement	Polarisation of the Washed Product	
Best refined . .	100·0	—	—	—	—	—	99·80	—	[illegible]
,, . .	100·0	—	—	—	—	—	99·90	—	,,
Java 15 . . .	98·2	0·47	0·231	0·29	0·806	95·50	96·90	99·0	,,
,, 17 . . .	94·6	1·97	0·329	1·95	1·160	91·00	91·25	99·7	
,, 16 . . .	95·0	2·34	0·250	1·20	1·220	89·84	89·67	99·0	
,, 14 . . .	97·0	1·39	0·310	0·70	0·710	94·17	94·22	99·5	
,, 12 . . .	95·5	2·00	0·240	1·90	1·440	89·90	89·22	99·0	
,, 11 . . .	95·4	1·50	0·070	1·25	1·320	90·87	91·75	99·1	
,, 9 . . .	95·2	2·00	0·720	1·70	1·030	86·80	88·60	99·1	
,, 8 . . .	89·5	4·84	0·846	2·40	2·281	80·45	83·18	99·0	1 p. c. sand
Surinam . .	86·8	4·06	1·440	5·30	2·410	76·25	81·30	98·0	
,, . .	87·0	3·61	1·190	5·70	2·050	77·54	77·85	97·0	
,, . .	80·0	4·01	1·070	4·23	1·480	79·64	82·15	92·0	
Bahia . . .	86·0	2·83	3·420	4·21	3·920	71·95	81·70	97·1	
Cuba . . .	85·7	3·37	1·330	5·00	4·090	76·08	70·23	96·0	
Madras . . .	82·0	0·10	2·050	6·10	9·150	69·60	78·14	98·0	
Berinam . .	90·5	2·20	0·600	2·68	3·040	84·09	84·12	97·0	
Porto Rico . .	85·0	5·40	0·480	8·01	3·340	63·29	82·01	98·0	
Manilla . . .	87·0	5·10	1·920	4·10	2·060	72·80	78·10	94·0	Much sand and lime
,, . . .	83·0	5·26	7·130	2·01	2·700	67·00	72·17	96·5	,,
,, . . .	86·6	4·41	1·720	4·53	2·740	73·60	81·00	96·0	,,
Beets:									
1st product . .	98·0	—	0·540	1·16	0·310	96·30	96·25	99·0	
,, . .	96·9	—	1·090	1·02	0·940	90·60	91·15	99·7	
,, . .	96·5	—	1·170	2·30	0·530	90·60	91·13	99·5	
2nd product . .	94·5	—	1·570	2·40	1·930	85·80	88·90	99·0	
,, . .	93·5	—	1·790	2·28	2·500	84·00	80·60	99·5	
,, . .	93·7	—	1·670	3·00	1·630	85·65	87·53	99·4	
,, . .	95·5	—	1·140	1·28	1·780	93·30	89·64	99·5	
,, . .	90·0	—	1·050	1·07	1·750	86·00	89·87	99·2	
3rd product . .	87·0	—	4·040	4·08	3·080	66·80	75·13	98·0	

SULPHUR. From numerous experiments, both on flowers of sulphur and on sulphur precipitated from an alkaline poly-sulphide, Signor E. POLLACCI found that, after being freed by washing from every trace of sulphuric acid, and then being exposed to the air in a moist state, they became oxidised, sulphuric acid being formed. This conversion of sulphur into sulphuric acid takes place very slowly at a low temperature, gradually at 25° to 30°, and rapidly at 65° to 70°.

POLLACCI also made experiments on the comparative rates at which Sicilian sulphur, and that from Romagna, undergo oxidation. The flowers of sulphur are most rapidly attacked, and the Sicilian sulphur the more slowly; everything depending on the powers of the sulphur to absorb air and moisture.—'On the Oxidation of Sulphur,' by E. POLLACCI, *Gazetta Chimica Italiana*, vol. v.

Where heaps of iron pyrites, mundic, have been exposed for years on the abandoned mines in Cornwall, and especially where it has been spread out upon the roads

decomposition goes on, according to the state of the atmosphere. Some sulphate of iron is formed, and in rainy seasons washed away, but thin layers of sulphur are often seen covering the beds and the roads, and if tasted this will be found to be intensely acid, oxidation, and the formation of sulphuric acid, having slowly gone on.

From Dr. A. W. HOFMANN's *Report on the Development of the Chemical Arts during the last Ten Years*, we extract the following on *The Sulphur Industry of Sicily*:—

'The miners who raise the sulphur ores are called *picconieri*, and work under the direction of foremen known as *capo mastri*. At the head of the establishment, immediately under the proprietary, there is now, generally, a scientifically trained mining engineer. The duty of the *picconieri* is to split out the sulphur ore from the veins, and to break it up, which is done with heavy hammers (*piccone*), weighing about 6 kilos., and sharpened on one side to facilitate the splitting. Gunpowder is very rarely used except where the gangue consists of the hardest limestone. The adits follow the direction and inclination of the veins, and branch out at places where the ore is rich and easy to work. In this manner are formed a series of spaces known as *gallerie* or *caverne* of every size and form opening into each other in the most various manner. The breadth of these galleries varies from 2 to 2½ mètres; their height fluctuates and depends to a certain extent on the thickness of the beds, and especially on the hardness of the rock enclosing the sulphur ores. Where this rock is soft it would be dangerous to give the galleries a greater height than two mètres, and to prevent accidents the sides are often supported by walls either run up dry or cemented with gypsum. The 14,000,000 to 15,000,000 quintals of ore furnished yearly by the 250 solfares of Sicily are almost exclusively transported by men and boys. Both in the galleries and up to the mouth of the pit the mineral is carried by thousands of boys from eight to ten years old, who convey the ore on their backs or shoulders. Only when the mine attains a depth exceeding 100 mètres this method of transportation is abandoned, both in accordance with the sanitary laws and from economic considerations. At such depths, and especially when water has to be removed, machinery must be brought into play or the mine abandoned. In such cases horse galleries have long been employed in Sicily, but if water has to to be lifted vertical shafts become necessary.

'Hitherto horse and cart galleries have only been introduced in four solfares, those of Montagna Vecchia (Province of Aragona), San Giovanello, and Montelongo (Province of Casteltermini), and Galleria Ercole (Province of Sommatino). According to statistical returns collected in 1865 this system has shown very favourable results.

'The first attempts at raising the ore by means of shafts were made at a solfare in the district of Bespica (Province of Villarosa), and in another on the Colle di Madore (Province of Serrara), by a French mining engineer named De Sabretaigne. They were carried on intermittently from 1859 to 1861, but the result was so unsatisfactory that they were given up. In 1865 similar experiments were made at the solfare of Montedoro, but with no better issue; and not until 1868 was the use of shafts seriously taken in hand and successfully carried out. This took place at the solfare of Grottacalda, at that time under the management of the mining engineer, PARODI, from whose report we take this brief extract. Here the shafts proved so advantageous that the same system was soon introduced in the solfares of Floristella, of Galizzi, and of others of less importance. The new arrangement at Grottacalda cost 78,000 lire; the shaft is 137 mètres in depth and has been in use for raising the ore since 1871. Since 1872 a steam-engine of 40 horse-power has been working in the great solfare of Sommatino. At the same time shafts were commenced at the solfares of Radusa, Montagna (Province of Sommatino), and Trabonella in the neighbourhood of Sanatra (Province of Caltanisetta), exclusively destined, however, for the removal of water. In place of the wooden pumps formerly in use metal pumps have been already introduced, which are managed by workmen named *trombatori*.

'If we compare the returns of the year 1867 with those of 1871 very notable progress will be perceived. Whilst at the end of 1867, 13 solfaras only employed 20 steam-engines, with a collective power of 256 horses, in 1872 21 solfaras are working with 400 horse-power. In the construction of the engines, which are not built on scientific principles, great improvements have been made. At the mouth of the sulphur mine each *picconiero*, with the help of his *manuali*, throws the ore he has raised into a heap (*cataste*), which is then measured by specially appointed officials. As a unity of measurement the *cassa* is employed, a vessel of the form of a parallelepiped, which in different mines holds from 2·6 to 6 cubic mètres.

'The extraction of the sulphur in Sicily is almost exclusively effected by fusion. The liquefaction in small cast-iron apparatus as is customary in some solfaras of the Romagna, or in earthen vessels, as described in manuals of chemistry, has never been in use in Sicily. As far back as tradition extends very primitive arrangements have been in use in the island, known as *calcarelle*.

'For this purpose round holes were dug in the ground of about 2·5 mètres in diameter and 4 decimètres in depth, in the midst of which the *picconiere* piled up the sulphur ores in a high mound, an operation which generally took up two days. This heap was set on fire in the evening, and in the morning of the next day so much liquid sulphur has collected in the outer part of the hole that it can be scooped out and cast into rolls—an operation which lasts till evening, and is resumed on the following day. This process involved little outlay, but the yield was small. Only one-third of the sulphur in the ores was utilised, the remaining two-thirds being diffused in the atmosphere as sulphuric acid, to the annoyance of the inhabitants and to the serious injury of the adjacent fields.

'Since 1850 the eliquation of sulphur in Sicily has been materially improved by the conversion of the *calcarelle* into *calcaroni*. The latter, as the word implies, are merely excavations like those described above, but on a much larger scale, and of an improved construction. They are large round cavities of a semicircular or semielliptical section, of about 10 mètres in diameter and 2·5 mètres in depth. They are generally contrived in places where the slope of the ground renders it practicable to arrange a communication from without with the lower part of the *calcarone*, the bottom of which is made inclining to this point.

'This external communication, curiously known as *la morte*, consists in an aperture 1·20 mètre high and 25 centimètres broad. Within the *calcarone* is lined with a wall of gypsum from 4 to 5 decimètres in thickness at the back (*i.e.* the part furthest from the opening) but from 1 to 1·2 mètre at the front. The masonry is lined with a smooth layer of gypsum, impenetrable by melted sulphur.

'The *calcarone* is charged by workmen known as *riempitori*. They cover, the bottom of which is either the mere ground, or, preferably, a hearth formed of hewn stone, first with a layer of finely-ground burnt ore from former operations, upon which follows a stratum of larger lumps of ore. Upon this formation the ore is heaped up, care being taken to put the smaller pieces principally on the outside of the heap. At the same time the outer communication is blocked up with a kind of vault, which is built up with large blocks of the poorest ore about its internal aperture. As soon as the cavity is filled up to the margin the workmen pile up more ore, forming a mound of the shape of a blunted cone, still keeping the larger blocks in the centre and the smaller about the circumference. By means of the large blocks it is found practicable to leave vertical chimney-like openings in various places, not too far from the margin and especially at the back of the *calcarone*, in order to regulate the draught. The mound is then covered with a stratum of finest powdered ore, over which follows lastly a coating of ground burnt ore, and known as the *shirt* of the heap (*camicia*). Before igniting the *calcarone* the outward aperture is closed with a thin wall of gypsum, in which small holes are left at various heights, and are closed during the combustion with balls of clay.

'The heat is kindled by means of bundles of straw dipped in sulphur and thrown into the draught flues. After about an hour all apertures are closed, and the mound is left to itself for eight or nine days. Then mingled vapours of water, sulphur, and sulphurous acid begin to make their way through the outer coating of the heap, and around the flues there appears a slight sublimate of sulphur. At the same time the barrier of the outward aperture becomes hotter and hotter near the ground, and finally red hot. By opening one of the holes which had been stopped with clay, it is possible to ascertain whether a sufficient quantity of melted sulphur, *olio*, as the workmen call it, has collected at the bottom of the furnace. Now begins the work of the sulphur casters; with a pointed iron bar they perforate the lower part of the gypsum wall, and collect the melted sulphur in moistened moulds of poplar-wood of the shape of a blunted pyramid. In this manner blocks of from 50 to 60 kilos. are obtained, and are sent to market without further preparation. The tapping and casting the sulphur are not everywhere conducted in the same manner. In some works the sulphur is allowed to collect till the end of the entire combustion and run off at once, but generally the *calcarone* is tapped twice or thrice in the course of twenty-four hours, so as to remove the sulphur as it collects. The *calcarone* is emptied and prepared for a fresh charge known as *scalcaratori* by the workmen.'

Sulphur in Washoe County, Nevada, U.S.—Some very remarkable sulphur beds have recently been discovered in Nevada. The following extract from a local newspaper (1877) gives the best account yet published:—

'The sulphur belt was discovered a few months since by Thomas Wheeler and Isaac Spencer, of Reno, who were prospecting in that section for cinnabar. The deposits have been opened by cuts and shafts at different points, extending north and south for a distance of half a mile or more. The sulphur is embedded in a light coloured, chalky appearing formation, strongly resembling steatite, which formation is half a mile in width, and can be traced northerly and southerly for at least a mile,

and, judging from the general surface appearances, it is reasonable to suppose underlies the whole extent of the magnesian formation. The sulphur has been found in most of the shafts and cut a very few feet below the surface. On the surface no escapes or indications of heat are visible, but in all the cuts and shafts great heat, steam, and gas have been developed a very few feet below the crust. The principal claim, known as the WHEELER and SPENCER, has been leased to JAMES DUFFY and THOMAS SMITH, of Carson City. These gentlemen have commenced the opening of the sulphur deposit on a point of the mountain some 150 ft. above the level of the flat, having secured for a foreman of the works the services of Mr. JOSEPH SCOTT, who is probably the best posted sulphur miner and prospector in the State. Mr. SCOTT opened the famous Rabbit Hole mine in Humboldt County, and has been a steady prospector in that line for several years past. The mine at that point has been opened to a depth of 20 ft. by running open cuts into the hillside, wide enough in which to turn a horse and cart. The cuts show the sulphur to lie in crystallised bunches and streaks, intermixed through and through the talc, or magnesian bed. Five or six tons of sulphur had been extracted, and lay piled up ready for shipment, and some fifty tons more were stripped, almost ready for extraction. At the bottom of the pit the heat was great enough to ruin the soles of a man's boots who would dare to linger there any length of time, and the sulphurous gases and steam made it a very uncomfortable place in which to labour. The appearances show, beyond a doubt, that a large and paying deposit of sulphur has been found. The sulphur, in its raw state, just as it is extracted from the mine, assays about 75 per cent. of the pure article, and is worth in the San Francisco market $60 per ton. These beds are within easy reach of the railroads, and if it is desirable a side track can be easily constructed almost to the mines.

'These hot, steaming beds of brimstone undoubtedly furnish a natural clue to the causes that operate the famous Steamboat springs, a mile and a half to the eastward. The formation underlying the sulphur beds is undoubtedly an immense ledge of magnesian limestone, filled with veins of iron, sulphur, and other minerals. Immediately in front, and overlying this bed of minerals, is a mountain of hard, syenitic granite. Back of it the mountain rises quite abruptly, and there is but little doubt that some of the small lakes formed by the melting snows on the table lands above find outlets through the open rocks into this bed, thus producing a decomposition of the minerals and releasing the carbonic acid in the limestone, which creates the powerful heat of the springs. The minerals are thus sublimated, and afterward condensed by the cold near the surface and left in the state in which we now find them. The first dip of the stratum, at the base of the mountain, is quite steep, and the flow of water following the strong inclination of the rocks, evidently passes underneath the belt of syenitic granite in front, and finds an outlet through the fissures and seams in the soft rocks beyond. The damming or closing up at times of these escape valves no doubt often confines the sublimated minerals and superheated steam to such an extent that it is forced to the surface with great power, which readily accounts for the mysterious exudation of the sediment and waters which so often takes place so forcibly, and has attracted so much attention from visitors.'—*Iron Age.*

JAPAN.—Sulphur is found in Ugo, Echigo, Shinano, Hizen, Matsu, and Osumi. It is impossible to obtain any estimate of the amount produced, although it is supposed to be considerable. A large quantity of sulphur is annually exported from Awomori to other parts of the empire.

MINES OF ITALY. (Vol. iii. p. 954.) In December, 1876, Consul COLNAGHI made a report to the Home Government on the province of Forli, in Florence. From that report, and a previous one made in 1875 and published in 1876, part ii. p. 372, we extract the following account of the sulphur deposits of the Romagna:—

'The sulphur deposits of the Romagna, which are of miocene lacustrian formation, are situated amid the sub-Apennine hills, and the mines now being worked in the province of Forli are spread over a superficial area of 260 square kilomètres. The outcrop of the rocks of sulphate of lime (gypsum), and those of carbonate of lime resting on grey clays or marls, denote the presence of the sulphur, which is covered with 10 or 12 strata of clays, interculated with gypsum under various aspects, wherever the water-courses have not in part destroyed them. The total thickness of these strata, to which the sulphur often conforms, is from 35 to 70 mètres. The direction of the sulphur beds is generally towards the north-west, oscillating between 22° and 68° NW., except at Perticara-Marazzana, where the strata lie ENE. (70° NE.). Here the mineral forms a lode, while at Predappio it is a mixture with limestone, gypsum, and marl.

'From a document existing in the archives of Ravenna, in which a parish of San Pietro, in Sulferina, in the district of Cesena, is mentioned, the existence of this mineral would seem to have been known in the eleventh century. In 1344, OSTASIO

da Polenta bought certain estates in the neighbourhood of Polenta, his right to dig for sulphur being expressly mentioned. The mineral is noticed in the poems of Dario Tiberti in the fifteenth, and of Folengo in the sixteenth centuries; and Georgius Bauer, or Agricola, in his work on Mineralogy, published in 1546, speaks twice of the sulphur of Cesena, and praises its quality.

'A law of the Pontifical Government of 1510 declared all mines to be State property, and Paul III., acting under it, annulled by brief of 1535 the privilege granted by his predecessor, Clement VII., to the Valeria, of excavating sulphur in the territory of Cesena. He transferred the privilege to the inhabitants of that city and district, giving them the right of preparing the mineral, and of freely selling the produce, save to infidels. This gave rise to the idea that the owners of land were entitled to work any mines that might exist under their property, an interpretation refuted by the Pontifical letters of Gregory XIII., in 1580, by which the rights and dues belonging to the State were recalled to vigour, and their imprescriptibility established. The brief of Paul III., of 1535, was still in force when the province of Forli was annexed to the kingdom of Italy, and has never been formally abolished. In 1865 a royal decree was published regulating the position of owners or workers of mines in the province with reference to the Government, embodying the principles of the Sardinian law on mines of 1859, which are inserted in each concession granted.

'From 1865 to 1870 the industry of which Consul Colnaghi treats does not appear to have progressed very favourably, and even the Società delle Miniere Zolfuree di Romagna, of which from 1855 to 1864 the profits had varied from 5 to 21 per cent., the average for the 10 years being 12·60 per cent., was not able in 1872 to pay the modest dividend of 3 per cent. without trenching upon its sinking fund. The company, with its fine mines, has, however, never made a profit owing to the absence of a complete network of good roads. In 1865 three of the mines only were easy of access for carts. Since then considerable improvement has taken place, and branch roads, where required, have been made at the expense of the companies interested. In 1872 the principal mines belonging to the Società delle Miniere Zolfuree Cesenate were purchased by an English company, with a nominal capital of 250,000*l.* sterling, and a new era of activity commenced for the sulphur region of the district in question.

'The chain of the Apennines of the province of Forli, Pesaro and Urbino, offers a large field for the growth of this industry. The total quantity of refined sulphur produced in 1874 amounted to about 24,700 tons. The profit per ton of refined sulphur is said to be from 2*l.* to 2*l.* 10*s.* The sulphur of Romagna is worth from 15 to 20 per cent. more than that of Sicily, on account of its intrinsic good quality and the degree of purity to which the refineries have brought it. The largest part of the production is used for sulphuring vines, and is readily consumed in Italy. In 1874 about 2,134 tons of Romagna sulphur was exported from the district of Ancona to France, Turkey, and Austria, and a certain quantity appears also to have been sent overland to the ports of Leghorn and Genoa for shipment. Consul Colnaghi, however, believes that there is very little, if any, exportation to this country. Foreign trade is as yet little acquainted with the value of the Romagna sulphur, the production of which has not long been brought to its present development. The facility of shipment of Sicilian sulphur naturally attracts trade to the south; but as soon as the position of the Romagna mines is bettered in that respect, there is but little doubt that the sulphur trade in connection with them will be enormously expanded.'

Consul Colnaghi describes several of the mines, but it appears necessary to confine attention to those of the Cesenate Sulphur Company:—

'On account of the large works for developing the mines many hands are required, and about 1,000 men, exclusive of carters, are employed. The men are maintained in excellent discipline by the combined means of regular payment and kind, but firm treatment. The only foreigners at the mines are the managing director and one English mining engineer, all the miners being Italians, and most of them natives of the district. The men work in gangs, three to 24 hours. Each miner is required to bore three holes in six hours, which being done the whole gang fire their mines together—an operation attended with great difficulty from the dense sulphur smoke developed, which renders respiration barely possible. The mineral is cleared away by the gangs of carriers and wheelers, and carried over tramways which extend to the headings. Each miner is paid the equivalent of about 1*s.* 3*d.* per tramload of 700 kilogrammes (1 kilogram equal 2·2046 lb. avoirdupois), and his earnings are estimated at one place to be from about 3*s.* to 3*s.* 9*d.* per diem; to make the latter sum, however, the gangs have to unite and work extra time. When stone only is found and no mineral, an allowance is made, to enable the men to live while working. The firemen are paid per ton on the production of the kilns, and their average earnings are about 2*s.* 6*d.* per diem, those of the carters being 1*s.* 8*d.* to 2*s.* 1*d.* per diem. The men live chiefly on bread, cheese, and vegetables, eating meat on Sundays. They spend much

on dress, and on holidays look like well-to-do people; they drink wine freely, but no spirits. They are more persevering at work than English workmen in cases of urgency, and many of them have remained underground for 24 consecutive hours when required. They are very obstinate in using their own tools and in working in their own way, and are accustomed to emphasise each stroke of the borer with their voice. These miners of the Romagna are quarrelsome among themselves, and ready with their knives; as a general rule they are superstitious, and are convinced that the spirits of those who have lost their lives through accidents in the mine hover about the works underground. The company have a store at the mine for the convenience of the men; but this *bettolino*, or tommy-shop, is on a better system than it was under the old management before the days of the English company. The wages are all paid in money, and the men are free to spend their earnings where they choose. A mutual relief fund has been established to assist the sick and wounded, and the widows and children of the men who may be killed. The company grants pensions according to the emergency of each case, but levies 2 per cent. on the men's earnings for the support of the fund, as well as towards the maintenance of the doctor, infirmary, &c.

'The SOCIETÀ DELLE MINIERE ZOLFUREE DI ROMAGNA was established in 1855. In 1872 this company's mines produced 58,412 tons of mineral, which yielded 7,873 tons of black sulphur. In 1871 the mineral produced was 58,108 tons, and the yield in black sulphur, 8,278 tons—the difference in product between the two years being caused by a falling off in the quality of the mineral extracted. Among the company's mines, those at Marazzana and Perticara are the most extensive; the latter, indeed, is one of the most celebrated and important sulphur mines in Italy. Mineral in lenticular masses averages 15 per cent. of sulphur. In the midst of the gypsum, the lower regular stratum, 2 mètres thick, averages 12 per cent. of sulphur.

'Works in 1874:—Galleries, &c., 5,800 mètres; facings, 240 square mètres; depth, 242. The interior works are conducted by a system of galleries, supported by pilasters, and they communicate internally with the Marazzana Mine. The Perticara Mine has been worked for 150 years, and, the works being deep and water present, the cost of extraction is heavy; compensation, however, is found in the excellent quality of the produce. The two mines of Marazzana and Perticara may be valued at from 30,000 to 35,000 tons of mineral per annum; the proportion of black sulphur is from 13·5 to 14 per cent., which would give about 4,000 tons of refined sulphur, taking into account the loss of 5 per cent. for refining.'

We find, upon referring to the Reports of Her Majesty's Consuls on the Manufacture, Commerce, &c., of their Consular Districts, that Mr. Consul GRANT, in his detailed statement of all merchandise exported at Venice in 1874, 1875, gives the value of the sulphur exported in Italian livres—

1874 . . .	705,750	1875 . . .	804,978

GREECE.—The island of Milo in 1875 exported 379 tons of sulphur clay, which was consumed in Greece and Turkey.

THE SULPHUR BEDS OF THE ISLAND OF SABA.—We have received an interesting description, by Professor GESSNER, of a visit made by him to the sulphur beds of the island of Saba. He says:—'Our destination was Spring Bay, where the beds of sulphur bearing gypsum show their greatest outcrop, and Great Hole, which adjoins it. The men were engaged in removing the overburden, some eight feet of sand and gravel, when we arrived, and in breaking down the crude brimstone from the face of the bed, which is forty feet in thickness at this point, and extends into the hill under the volcanic cap for an indefinite distance. Going towards Flat Point, which lies between Great Hole and Spring Bay, and descending the cliff a little, one can obtain a view of the face of the vast bed of brimstone, which shows the yellow features in all the places where the overburden has been removed, and in weather-worn places stands out distinctly. At one place a fissure nearly two feet in width, lined with yellow crystal so far as we could see, was sounded with a line for forty feet. The mass of the bed is gypsum, bearing sulphur to a greater or less degree, 60 per cent. being the average of sulphur. In many places masses of sulphur quite pure, and resembling melted brimstone poured into irregular moulds, could be had hundreds of pounds in weight. The fires died out in Saba so long ago that the sulphur-beds are perfectly cold, and no gases arise to interrupt the working of the sulphur quarry, the workmen carrying on their operations as easily as if in a bank of stiff clay. We trace the bed to Flat Point, and agree as to what Spring Bay will show when its outcrops have been explored with pick and shovel. We discuss the shipping facilities, and agree that a wire tramway from the edge of the quarry to Green Key will be the way to do the transportation to the lighters. I have seen what I believe to be one of the largest, and certainly the richest and most accessible, deposits of brimstone in the world.'

Mr. G. G. Blackwell sends us the following:—

Analysis of Soba Sulphur.

No. 1.

Sulphur	80·57
Silicate and sulphate of lime	14·90
Water	4·53
	100·00

No. 2.

Sulphur	75·81
Silicate and sulphate of lime	20·56
Water	3·63
	100·00

Chemical News, vol. xxxi. No. 811, p. 262.

SULPHURETTED ORGANIC COLOURING MATTERS. See Dyeing. 'Croissant and Bretonnière find that each of the solid dye wood extracts contains the tannin peculiar to it, and gallic acid; the decomposition extract of tannic acid yields, when heated to about 250° C., metagallic acid. They make use of this reaction in the case of logwood extract, and have obtained, with liberation of carbonic acid, a black voluminous body insoluble in water, easily soluble in alkalis, precipitated by acids in brown flocks, and giving, with different metallic salts, differently coloured precipitates.

'The alkaline solution of the substance thus obtained from logwood extract possesses an uncommonly strong attraction, as a dye, for vegetable fibre. It is well known that if other organic substances be subjected to the action of alkalis at high temperatures, an oxalate is formed. If, however, sulphur be introduced, it either enters into combination with the substance, or unites with a portion of the hydrogen and, as sulphuretted hydrogen, escapes. In either case, from almost all organic substances, new bodies are formed, which fix themselves on vegetable and animal fibres without the need of mordants, producing good tints, which are perfectly fast.

'The discoverers find that the most dissimilar substances heated in closed vessels with the sulphide or the polysulphide of sodium give rise to similar colouring bodies. All the dyewood extracts, humus, saw-dust, tannin, paper-cuttings, bran, flour, blood, glue, excrement, urine, and woollen and silk fragments, yield colouring matters. These form themselves in the shape of a bulky and more or less dark-coloured mass by this treatment. Within the limits of 200° and 300° C. the increase of temperature improves the solubility and the beauty of the product obtained, and also its capacity for resisting the action of light.

'All these dyes are very hygroscopic, and they must be preserved in well-closed metal boxes. After four or five months' exposure they become insoluble and useless. A dye bath prepared from them should be used as fresh as possible, and exhausted before leaving it. The colour may be entirely withdrawn from the solution by vegetable or animal fibre.

'The water with which the solution is made must be free of lime. The colouring matter is precipitated from its solution by acids, but the precipitates are re-dissolved in alkaline solutions.

'Bichromate of potash acts as an oxidizing agent, and this salt serves as an important agent in fixing these colours on yarn or cloth. The colours so fixed are proof against acids, so that ink spots may be removed from the dyed goods by oxalic acid, without injury to the colours.'—Croissant and Bretonnière, in Dingler's *Polyt. Jour.*, ccxv.

SULPHURIC ACID. *On the Manufacture of Vitriol in Bohemia.* By E. V. Jahn.—The raw material of this peculiar branch of mineral industry is furnished by the slates of the Przibram group of the Lower Silurian strata, which either resemble the older azoic schists forming the so-called barren slates, and are to some extent used for roofing purposes, or contain carbonaceous matter and pyrites (the latter mineral varying in amount from 1 to 31 per cent.), forming the so-called alum, or more properly vitriol, schists.[1] Although called a schist, it is essentially a sandstone or quartzite, containing about 12 per cent. of pyrites and sulphate, 6½ per cent. of coaly substance, 76 per cent. of silica, and only 1·2 per cent. of alumina, which composition

[1] The same thing is observed in roofing slates, like those of Delabole, which are very durable, though full of small bright cubes of pyrites. When, however, a film of pyrites occurs on a cleavage surface, such as are often residue of fossils, a brown rusty stain is soon formed when the slate is exposed to the air.

sufficiently accounts for the circumstance that the alum works started at this place in 1678 did not flourish. These are distinguished from the barren or roofing slates by the darker colour and higher specific gravity, and occur in beds of usually considerable size, or from a few feet up to 20 fathoms thick underlying the coal measures of Pilsen. By exposure to the action of air and water the pyritic constituent gives rise to sulphates, and if the schist is sufficiently aluminous it can be used for alum-making, but if, as is the case in the Pilsen district, the proportion of alumina is small and that of pyrites large, iron sulphates are produced in quantity, and the material is then utilised for the production of copperas, sulphuric acid and iron colours. The original seat of the manufacture of sulphuric acid was in Bohemia in the sixteenth century, whence it spread to Nordhausen, in Saxony, and the Harz, and although the name Nordhausen acid is still kept up, the production has long since ceased at that place, and the manufacture has returned to its original home. The revival of the process in Bohemia is due to the late J. D. Starck, who founded small works on the Saxon frontier in 1792, which, by the gradual addition of other factories and collieries, has resulted in a group of establishments worked by the same firm, the produce of which in 1873 was valued at 403,000*l.*, and included about 400,000 tons of coal and 25,000 tons of vitriol and allied substances. The principal deposit is at Hromic, where a bed of 120 feet thick is worked in open cast, the average thickness of cover being about 11 fathoms. The bottom of the present working is about 23 fathoms deep, and it is intended to carry it about 7 fathoms deeper. The available amount of material is estimated at 9,500,000 tons, of which about 630,000 tons has been raised during the last thirty-five years. The ore, when raised, is broken to a uniform size by rock-breakers, and arranged upon floors in terraced piles, channels being made through the mora regular intervals both in vertical and horizontal directions in order to promote atmospheric oxidation and facilitate the washing out of the soluble salts formed. For the complete decomposition or weathering of the schist about three years are required, the operation being facilitated by the addition of water, which removes the sulphates, forming a brown lye whose density is from 18° to 20° B. This is received in open storage casks, where it remains for a greater or less time according to the requirements of the boiling-house, the strength and proportion of ferric salt becoming slightly increased by evaporation and oxidation. The lye is boiled down in open pans set in a reverberatory furnace, the flame passing over the surface of the liquid. When sufficiently concentrated (40° B.) the ashes and soot deposited on the surface are removed, and the liquid is boiled down to the consistency of treacle in iron pots, which, when run out on the floor and cooled, form the so-called crude vitriol stone. This contains a large quantity of unaltered ferrous sulphate and water, and is heated in a reverberatory furnace to drive off the water and decompose the ferrous salt, whereby it is converted into calcined vitriol stone, which is essentially anhydrous ferric sulphate. At Hromic about 2,000 tons of this substance were produced in 1872, the amount of schist raised being 20,000 tons, about six years' supply; about 1,000 tons more being made at the smaller mines belonging to the firm. To produce 1 ton of calcined vitriol from 6 to 20 tons of schist are required. The best results are obtained from schists in which the pyrites are finely interspersed through the mass and not in well-defined crystals, as the latter are not liable to decomposition and may be removed unaltered after several years' exposure to the weather. The calcined schist stone is converted into fuming sulphuric acid (oil of vitriol) by distillation in clay retorts arranged in series in the so-called gallery furnace. The yield varies with the quality of the stone, the best giving 50 per cent. of 'oil,' while if the calcination is not properly done it is as low as 33 per cent. The work is divided over twelve establishments, containing 120 furnaces. Each furnace contains 4 horizontal rows of 34 retorts, each projecting from the face of the longitudinal wall, which are placed back to back with a similar series on the corresponding wall. Above these is a series of 34 large retorts open at both ends going right across the furnace, and having a receiver adapted at either end. The smaller retorts are clay bottles with wide necks, into which are placed the necks of the receivers, which are of sufficient capacity to receive the product of 4 or 5 distillations, the joint being luted with clay. The furnace therefore contains 272 small and 34 large retorts, with 340 receivers. The average charge is about 1½ lb., the heat being slowly raised, the lower row of retorts being red-hot in about 4 hours, up to which time they are left open in order to promote the formation of ferric sulphate. The receivers are then attached, and are filled either with 15 ozs. of rain-water or an equal amount of English or chamber acid of 66° B., in which the vapours of anhydrous sulphuric acid are condensed. In the former case, which is followed when a pure product is required, the charge in the retorts must be renewed four or five times to obtain fuming acid of 79° B., but when chamber acid is used the product is brought up to 80° by three or four charges. The number of retorts consumed annually is 724,000, and of receivers 40,000, or only

one-half of the quantity formerly required. When the acid has attained the necessary concentration, which is determined by the rapidity with which a splinter of wood is blackened, it is poured into clay bottles, where the mechanically intermixed impurities are allowed to settle, so that the clear acid can be drawn off. When the specific gravity is not sufficiently high, it is sometimes brought up by adding anhydrous sulphate of soda, a practice which is, of course, detrimental to the interests of the purchaser. When chamber acid is used for condensing, the product is affected by the impurities of the former, so that it may be unfitted for use where great purity is required. The residue in the retorts, known as colcothar, caput mortuum, rouge, &c., is locally called colour (*barvu*), is scraped out after each distillation, and is of different tints according to the temperature at which it is produced. Formerly it was unsaleable, and accumulated in heaps round the works, but by the adoption of a special treatment it has been converted into various kinds of red paint and rouge, of which from 1,100 to 1,300 tons are prepared yearly, nineteen shades and forty-one classes of colour being prepared. The principal consumption is in Hamburg for colouring iron ships. In 1872 there were produced from 2,928 tons of calcined vitriol stone, 1,720 tons (58·4 per cent.) of fuming acid, and 968 tons (33½ per cent.) of caput mortuum. The raw material from the retorts, after grinding between French burr-stones, is reheated in clay tubes with an addition of common salt. Yellow tints are produced, with 2 per cent. of salt, by heating for 1 hour and slowly cooling; brown with 4 per cent., and violet with 6 per cent., the material being heated for 6 hours and rapidly cooled.—*Oesterreichische Zeitschrift für Berg- und Hüttenwesen*, vol. xxiv. p. 497.

SUPERPHOSPHATES, THE MANUFACTURE OF. M. Cloëz gives a report in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, No. 17, 1875, on the superphosphate works of MM. Michelet and Thibault. In this establishment the phosphates are mixed with the acid in closed vessels, from which the noxious vapours are drawn by an aspirator; they then are made to traverse a tower filled with wet coke, and pass finally into the chimney of the works. The phosphatic minerals employed are those of the Lot, the Ardennes, and of Estremadura. These are ground and sifted for use, and it is said that the vapours given off by the phosphates from the Lot yield a small quantity of iodine.

SURVEYS, MINE. *An improved Method of Measuring in Mine Surveys, by* Eckley B. Coxe, Drifton, Pa.—'In making surveys in the anthracite coal regions of Pennsylvania, the ordinary engineer's chain (50 or 100 feet long) is generally used, both above and below ground. Sometimes, where it is difficult to chain, as, for instance, across a chasm, a wire is stretched from one station to the other; the distance is marked on the wire and its length is then measured with the ordinary chain. Having had occasion lately to make some surveys where it was necessary to determine with great accuracy the position of the land or property line, not only in the gangways or levels, but also in the breasts or chambers, the coal on the north side of the line belonging to one party and that on the south side to another, and as it is very difficult to measure up the breasts or slopes with accuracy, and to make the proper allowance for the pitch of the vein (the true horizontal distance being, of course, the product of the distance measured with the chain by the cosine of the angle of inclination of the chain), and as the ordinary method of chaining up or down steep slopes on the surface, by holding a portion of the chain horizontal and plumbing down from the high end, would in most cases be very difficult and dangerous, and sometimes impracticable, I determined to adopt a new plan which would do away with most of the above difficulties, and by which I could eliminate many causes of error from my ordinary chaining.

'My first idea was to have a fine steel-wire rope, about 300 feet long, stretched as much as possible in making, so as to do away as well as I could with that source of error, and then to have it graduated every 10 feet. I proposed using small brass tags of different shapes to designate the different hundred feet, thus:—

0—100 a triangle.
100—200 a square.
200—300 a circle, &c.

'The numbers of the 10 feet spaces were to be marked by drilling small holes in the tags. I intended to use this for the principal lines of my surveys and to use the chain only for lines which were not of great importance.

'When I called upon Mr. Heller (of Heller and Brightly, the instrument makers, of Philadelphia) to order this measure, he suggested that it would be better to use instead of a wire rope, which would stretch, the bands which are manufactured for hoop skirts; they are made of tempered steel, are very light, and will not stretch

sensibly. After consultation with him, I decided to have the tape measure constructed which is now before you. It is 500 feet long and weighs 3 lb. 7¼ ozs. It is a ribbon of tempered steel, 0·08 inch wide, 0·016 inch thick. At each 10 feet a small piece of brass wire is soldered across the tape, the solder, which is white, extending about 1 inch on each side of the wire. In the latter a small notch is filed, which marks the exact spot where the 10 feet ends. The exact distances from the zero point of the tape are marked upon the solder by countersunk figures. The white solder enables one to find the 10 feet notches very easily, and, no matter how dirty the tape may be, by wiping off the solder with the finger, the distances are easily read, as the countersunk figures, being filled with dirt, stand out upon the white ground of the solder. The 0 and 500 feet marks are not at the end of the tape, but near it, and are also denoted by a notch filed in a wire soldered to the tape.

'The tape is wound upon a simple wooden reel, 10 inches in diameter, which is held in one hand and turned by the other. At first some difficulty is experienced in winding up the tape, but a little practice soon overcomes it. Two brass handles, which can be detached, accompany the tape and are carried upon the reel.

'*Description of a Survey made with the Tape.*—The instruments used were one of HELLER and BRIGHTLY's new 11-inch transit, two plummet lamps, the 500-feet tape, and a 5-feet wooden rod divided into feet and tenths. The latter is used to measure the distance from the nearest 10 feet to the station. There were two closed sets of lines or surveys, one set entirely above ground, but through the swamps and brush of the anthracite coal region, and one partly above ground and partly in the mines. The latter began at a point in the swamp, went overground 2,400·57 feet to the mouth of the slope, then down the slope (pitch 37°), 276·99 feet (horizontal distance), then along the gangway 4,272·01 feet, which formed one-half of an ellipse, then up through a breast (pitch about 34°) 275·44 feet (horizontal distance) to the bottom of an air-shaft, then by two plumb lines to the surface, and then through the swamp 141·83 feet on the surface to the point of beginning. The length of the periphery of the first closed figure was 6,660·19 feet; that of the second 7,366·84 feet. Tables I. and II. show the details and calculations of the two surveys.

'We see that the total errors were in the—

	Sine	Cosine
First case	+ 0·29	0·00
Second case	− 0·02	+ 0·62

'This is very accurate work for this kind of mine surveying. We made three other surveys on the same property with equally good results.

'In measuring with the tape it is better to have at least three men, one at each end and one to take off the distances and note them. The hind chainman should be a reliable man, as he must hold the zero point of the tape exactly at the nail in the stake, or alongside of the cord to which the plummet-lamp is suspended. The front chainman has merely to stretch the tape and to see that it passes exactly over the front station. The third man, who carries the 5-feet rod, starts from the rear station and notes the distances of the breasts, &c., as he goes along until he arrives at the forward end, where he notes the distance of the station from the last one. In measuring distances of over 500 feet a temporary station is made at 500 feet exactly in the line to be measured.

'*Advantages of the Tape.*—First, greater facility in measuring up or down slopes, breasts, &c. Second, greater accuracy in measuring from one station to another, as the tape forms a straight line from one station to another, and as there is no error from the use of pins. Third, the tape does not stretch appreciably.

'*Disadvantages.*—First, it is liable to break unless carefully handled. Second, it is necessary to roll it up and unroll it, when the distances between stations vary much.

'The tape can be easily mended by any watchmaker when it breaks, and Messrs. HELLER and BRIGHTLY make a small sleeve of brass, tinned inside, in which the ends of the tape, when broken, are slipped and then soldered fast by merely heating the sleeve with a red-hot poker. They also have little brass clamps to fasten on the tape to mark any point which is to be used several times.

'When the men become accustomed to the tape they wind it up and unwind it very quickly.

'There are three sources of error which may be referred to, viz.:

'1. The extension of the tape by stretching.

'2. The shortening of the tape in consequence of the tape assuming the form of the catenary curve.

'3. The contraction or expansion due to the change of temperature.

[1] As stated above, the tape does not stretch appreciably, but this error being in the opposite direction, is, to a certain extent, compensated for by the shortening due to

TABLE I.

Station	Angle Right	Angle Left	Reduced Angle	Distance	Positive Sine	Negative Sine	Positive Sum of Sines	Negative Sum of Sines	Positive Co-sine	Negative Co-sine	Positive Sum of Cosines	Negative Sum of Cosines
I	0° 04'	—	0° 04'	664·97	0·78	—	0·78	—	664·76	—	664·76	
2	0° 47'	—	0° 45'	711·60	10·34	—	11·34	—	711·47	—	1376·23	
3	—	0° 52'	− 0° 07'	408·00	—	0·12	11·22	—	408·16	—	1784·39	
4	0° 32'	—	+ 0° 25'	607·25	5·28	—	16·50	—	607·22	—	2391·61	
5	—	179° 23'	−179° 08'	196·05	—	3·21	13·29	—	—	196·03	2195·58	
B	—	61° 15'	−240° 15'	95·42	44·45	—	57·74	—	—	70·45	2089·16	
B1	—	19° 36'	−229° 51'	358·50	297·72	—	355·46	—	—	231·18	1858·01	
B2	—	9° 36'	−239° 27'	601·00	542·41	—	896·87	—	—	230·73	1617·28	
B3	4° 06'	—	−235° 21'	381·35	313·62	—	1212·49	—	—	216·77	1400·51	
B4	36° 51'	—	−198° 30'	735·00	250·37	—	1462·86	—	—	700·03	900·48	
B5	62° 50'	—	−135° 47'	304·60	—	201·67	1260·59	—	—	214·54	576·04	
2	—	6° 01'	−141° 48'	577·50	—	296·53	964·06	—	—	450·04	—	60·00
1	50° 27'	—	− 90° 21'	464·50	—	330·01	594·75	—	230·07	—	176·07	
3	—	44° 17'	−103° 38'	210·00	—	204·14	390·61	—	—	49·60	127·47	
4	—	3° 51'	−100° 29'	345·20	—	260·85	+0·29	—	—	127·17	0·30	
					1460·23	1460·03			2588·57	2588·57		
				Difference +0·20				Difference 0·00				

TABLE II.

Station	Angle Right	Angle Left	Reduced Angle	Distance	Positive Sine	Negative Sine	Positive Sum of Sines	Negative Sum of Sines	Positive Co-sine	Negative Co-sine	Positive Sum of Cosines	Negative Sum of Cosines
B	—	30° 12'	−240° 15'	85·42	44·48	—	87·74	—	—	70·45	2089·16	
B1	—	19° 36'	−229° 51'	358·50	297·72	—	355·46	—	—	231·18	1858·01	
B2	—	9° 36'	−239° 27'	601·00	542·41	—	896·87	—	—	230·73	1617·28	
B3	4° 06'	—	−235° 21'	381·35	313·62	—	1212·49	—	—	216·77	1400·51	
B4	36° 55'	—	−198° 06'	735·00	250·37	—	1462·86	—	—	700·03	699·48	
B5	31° 20'	—	−166° 06'	137·90	—	33·64	1430·30	—	—	134·01	436·57	
C	72° 10'	—	− 94° 35'	270·90	—	273·99	1154·04	—	—	23·00	412·47	
1	86° 44'	—	− 6° 18'	661·09	—	70·00	1083·74	—	648·20	—	1060·70	
2	—	11° 05'	− 17° 44'	157·06	—	48·01	1035·73	—	149·34	—	1210·30	
3	6° 41'	—	− 11° 07'	281·80	—	54·29	981·48	—	276·35	—	1486·65	
4	8° 31'	—	− 2° 40'	86·20	—	4·10	977·38	—	86·79	—	1573·31	
5	—	9° 30'	− 12° 12'	193·21	—	40·77	936·49	—	188·44	—	1761·88	
6	—	4° 31'	− 16° 43'	208·15	—	59·88	876·52	—	198·88	—	1960·73	
7	2° 17'	—	− 14° 26'	235·88	—	58·70	817·81	—	228·40	—	2189·13	
8	—	7° 00'	− 21° 00'	470·32	—	178·30	639·51	—	441·08	—	2630·91	
9	4° 09'	—	− 17° 50'	101·30	—	31·04	608·12	—	96·52	—	2727·13	
10	—	7° 30'	− 25° 46'	235·64	—	102·56	506·06	—	212·15	—	2939·27	
11	18° 50'	—	− 6° 58'	370·64	—	44·00	460·06	—	368·11	—	3307·38	
12	—	61° 46'	− 68° 44'	80·40	—	72·68	387·10	—	44·54	—	3352·29	
13	—	44° 30'	−108° 14'	99·90	—	87·60	299·50	—	—	22·65	3329·34	
14	—	76° 31'	−182° 06'	316·50	11·61	—	301·11	—	—	316·30	3013·04	
15	14° 36'	—	−167° 00'	151·53	—	33·80	267·31	—	—	147·68	2865·48	
16	13° 06'	—	−155° 28'	107·05	—	47·38	220·13	—	—	97·40	2768·48	
17	—	15° 30'	−169° 29'	123·30	—	22·55	197·58	—	—	121·29	2647·19	
18	—	13° 13'	−182° 47'	209·60	9·88	—	207·51	—	—	209·37	2437·82	
19	—	4° 40'	−157° 27'	176·24	23·00	—	230·51	—	—	177·65	2260·17	
20G	[illegible] 10'	—	−199° 10'	31·31	—	16·95	213·55	—	—	13·55	2246·62	
F	34° 44'	—	−164° 29'	173·71	—	167·56	45·97	—	—	43·44	2203·64	
E	34° 10'	—	− 70° 19'	73·62	—	73·19	—	27·65	26·20	—	2229·37	
D	22° 50'	—	− 49° 30'	9·09	—	6·78	—	34·60	6·04	—	2235·31	
C	—	19° 06'	− 67° 29'	36·86	—	33·87	—	68·57	9·94	—	2245·25	
A	—	154° 46'	−222° 14'	106·80	71·91	—	12·24	—	—	73·05	2168·20	
B	43° 15'	—	—	—	—	—	—	—	—	—		
					1666·25	1666·27			2389·13	2391·60		
					Difference −0·02			Difference +0·03				

the formation of the catenary curve by the tape. I subjoin a table, calculated by my assistant, Mr. Edgar Kublich, showing the shortening of the tape due to the latter cause. The tension in practice is from 30 to 40 lb.

[2] According to the table given by Haswell for the expansion of steel, a tape measure 500 feet long at 32° Fahr. would become 500·4 feet long at 212°, so that a variation

of 60° in temperature would only cause a variation of two-tenths of a foot in a 500-feet tape.

TABLE III.

Length of Tape Measure	True Distance when Tape is subjected to a Tension of (or Cord of the Catenary Curve formed by the Tape)—					
	10 lb.	20 lb.	30 lb.	40 lb.	50 lb.	60 lb.
100 feet . .	99·9894	99·9974	99·9988	99·9993	99·9995	99·9997
200 „ .	199·9153	199·9701	199·9907	199·9948	199·9967	199·9977
300 „ .	299·7143	299·9294	299·9687	299·9821	299·9887	299·9922
400 „ . .	399·3256	399·8327	399·9260	399·9583	399·9733	399·9815
500 „ . .	498·6776	499·6732	499·8551	499·9185	499·9470	499·9628

'In conclusion, I would advise the use of the tape for all important work, while the chain should be used for filling in details, and where accuracy is not absolutely necessary.'—*Transactions of the American Institute of Mining Engineers*, vol. ii. (See DIALLING.)

SUSPENDED HOT-BLAST STOVES. (Vol. ii. p. 956.) In IRON AND STEEL, Mr. COWPER's hot-blast stoves are described at p. 461; Mr. CROSSLEY's hot-blast stove at p. 462; and Mr. WHITWELL's is fully illustrated in vol. iii. p. 961.) The following description of another variety of hot-blast stove is by Mr. JOHN BIRKINBINE, of Philadelphia:—

'The apparatus at present most prominently before metallurgists, in connection with heated blast, is the WHITWELL stove, and it is fully entitled to the credit given to it, but, unless the increased temperature attainable with the firebrick stoves be practically demonstrated to be of sufficient value to compensate for the additional first cost, the expense of construction will prevent their general adoption. The erection of WHITWELL stoves, sufficient to maintain a uniform temperature of a hot blast, will, at the present time, cost about two-and-a-half times as much as well-constructed pipe-ovens for the same furnace.

'Much of the trouble with pipe hot-blast stoves originates in defective construction and want of care in operating them. During a visit made last year to a prominent Western furnace plant, the writer observed a syphon-pipe hot-blast oven being torn down after a short blast. The pipes were, to use the founder's expression, "very drunk," and the oven was in very bad condition. An investigation left little room for surprise. The gases were discharged from the downcomer into a small masonry channel as an apology for a combustion-chamber, which was not supplied with any air-regulating apparatus, and the flame, in some instances, impinged directly upon the pipes. An examination of some of the broken pipes demonstrated that they were imperfectly cast of inferior metal, the shell in one instance being two inches thick on one side, and about half an inch thick on the opposite side. It is in the comparison with such constructions that the permanency of the firebrick stoves appears to great advantage. Where the pipes are made of good metal, cast in dry sand, with core and mould concentric, and set in ovens well built and stayed, provided with a proper combustion-chamber, and gas-burners under perfect control, so as to obtain a thorough combustion and fill the pipe-chamber with a highly heated atmosphere, the apparatus is by no means a temporary one, and may be run for years without renewals or repairs. As an instance, the oven at one of the furnaces of GROVE BROTHERS, at Danville, to which the combustion-chamber was first applied in 1850 (fifteen years before it was patented in England), is still in use and in fair condition. Unless some means are found of greatly reducing the first cost of the firebrick stoves, our furnaces will continue to depend upon pipe-ovens; and it is my privilege to invite your attention to an improvement, which, I believe, will do much towards cheapening the cost of construction and maintenance of iron-pipe hot-blast stoves. In its presentation I desire to say that, believing the subject is of great interest, I obtained from the inventor the privilege of presenting it here, and thus subjecting it, in its infancy, to the candid criticism of many of our best ironworkers.

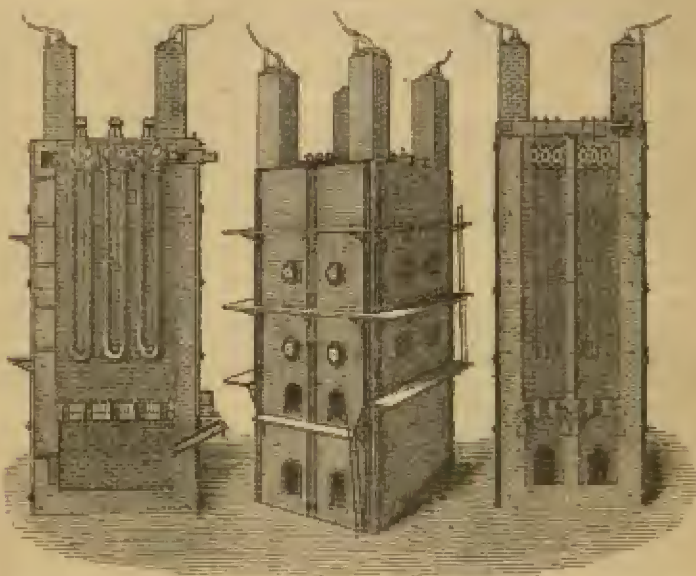
'Mr. WEIMER's oven contains eighteen U pipes, 20 ft. long (*fig.* 2547). The cross-section of the pipe is an ellipse, 12 by 4 in. inside measurement, and the heating surface of each pipe 109 sq. ft. The usual bed-pipes are dispensed with, and the U pipes are suspended from the top of the oven by means of suspension bolts and beams.

'To overcome the difficulty of maintaining a uniform heat in the combustion-chamber, two chambers are used, each 7 ft. high, 3 ft. wide, and 10 ft. long—shortening the chamber and increasing its height having proved efficacious in equalising

the temperature. Besides the usual gas-jets a series of 1 in. air-pipes are walled into the sides of the gas-chambers, so that the air may be thoroughly diffused throughout the mass of gas supplied to the chamber.

'There being no bed-pipes to interfere with the arrangement of the flues connecting the combustion and pipe-chambers, they can be arranged so as to give a uniform distribution of heat in the pipe-chamber. These openings are made 6 in. square. The pipe-chamber is also divided into two compartments, each of which is 4 ft. wide, 12 ft. long, and 24 ft. high, placed above and communicating with its own combustion-chamber, entirely independent of its neighbour.

2517



'This arrangement obviates the difficulty of the hot and cold sides of the stove, and prevents the heat from becoming excessive on either side. There are no doors to the pipe-chamber, a few explosion-valves and sight-holes, the latter acting also as cleaning-holes for removing dust by steam-jets, alone breaking the continuity of the walls, which are made 22 in. thick, to prevent radiation and to support the weight of the pipe and mains.

'On the top of the front end wall a short main 12 in. × 14 in. × 6 in. is placed, having on one side a connection for the cold-blast pipe, and on the opposite side three branches corresponding in cross-section with U pipes. To these branches three rows, each of three U pipes, are connected, and extend across the oven to a longer main placed on the rear end wall. This main has six branches, three in each chamber, the blast passing into it from the three rows of pipes in one chamber, and out of it into the three rows of pipes in the adjoining chamber, and through them into a short three-branch main connected with the hot-blast pipe. The branches of the mains and the ends of the U pipes have flanges which are planed to a true surface and connected by means of keybolts. Lugs are cast on the top of each arm of the U pipes to which suspension-bolts are secured; these bolts pass through saddles or washers, resting upon short 15 in. I beams, supported upon the side walls of the oven. The entire masonry of the oven can therefore be constructed before the pipes are placed in position.

'Just below the connecting flanges of the U pipes, small projecting collars are cast, upon which (after the pipes are placed) fire bricks are laid, forming a roof, and protecting the joints from the action of the heat. On the top of the side walls an iron wall-plate is laid, which can be continued from one stove to the other when they are in a row. This plate is cast with a projecting rib, so as to form a rail, upon which wheels of a truck carrying a crane or derrick may run. By this means a pipe, which may have become damaged, can be readily removed and another put in its place in a short time.

'But, from the construction of the stoves, the necessity of frequent renewals is not probable, for the pipes are placed to sustain the greatest amount of heat with the least possible fatigue on the metal; their pendent positions and swelled bottoms have a tendency to keep them straight and prevent warping, the swelling also placing a surplus of metal where oxidation is the most destructive, thereby aiding in equalising the life of the entire pipe.

'In these ovens there is no metal in the lower oxidising atmosphere in the pipe-chamber, the bottom of the pipes being 4 ft. above the floor of the chamber; but, on the contrary, the heating surfaces of the pipes are thrown into the upper and more uniformly heated portion of the pipe-chamber, which, in the ordinary standing pipe-stoves, is necessarily left vacant.

'Among the additional economic features of these stoves are the following:—

'There being no bed-pipes, there is a corresponding decrease in the weight of castings required.

'The absence of door openings simplifies the masonry and lessens the castings required.

'There being no other duty upon the arch over the combustion-chamber than that of a dividing wall, considerable staying can be dispensed with.

'The convenience of removal, by merely removing a section of the brick or tile roof (which rests upon the collars cast on the U pipes), and driving out the keys of the desired pipe, will materially lessen the cost of necessary repairs.'—*Transactions of the American Institute of Mining Engineers.*

SYLVANITE. One of the names given to an ore of tellurium found in North Carolina.

SYLVIN. A chloride of potassium. The colourless crystals have been found in the salt mines of Stassfurt, Prussia, and with them a blue variety. Yellow and rose-red crystals are also found.—G. KRAUSE, *Arch. Pharm.* See *Glossary of Mineralogy*, BRISTOW.

SYMPALMOGRAPH. This is the name given to a machine for drawing and illustrating LISSAJOUS' curves. In the *Annales de Chimie et de Physique*, 1857, M. LISSAJOUS describes his machine as follows:—

'The problem of which I have undertaken the solution is the following: To compare, without the help of the ear, the vibrating movements of two bodies in such a manner as to know the exact relation of the number of vibrations that they make in the same time, as well as all the circumstances which, during the continuation of the phenomena, characterise their relative movements.'

Briefly stated, he accomplished this by setting two tuning-forks vibrating at right angles to each other—that is, one mounted vertically, the other horizontally. Both were provided with small mirrors, and a beam of light was projected on to one mirror, reflected thence to the other mirror, and from the second mirror sent through a lens on to a screen. The resulting images of the two forks are in the one case vertical, in the other horizontal. If both forks vibrate together, the two motions combine, and the reflected pencil describes a more or less complex curve, the form of which depends on the number of vibrations of the two tuning-forks in a given time. This curve gives a valuable means of computing the number of vibrations of two sounding bodies. In describing the combination of two vibrating motions in the same direction, LISSAJOUS says: 'If the tuning-forks pass their position of equilibrium in the same time and in the same direction, the image attains its maximum, and the image is at its minimum when they pass at the same time, but in opposite directions. Between these two extreme cases the amplitude of the image varies according to the time which elapses between the exact instant at which the tuning-forks pass through their positions of rest respectively. The ratio of this time to the time of a double vibration is called a *difference of phase* of the vibration.'

The accompanying diagrams, copied from LISSAJOUS' paper, will convey some idea of the character of these curves. They are an optical study of two vibratory movements at right angles to each other.

A very simple and beautiful form of the sympalmograph has been constructed by Mr. W. MORGAN BROWN, who has favoured us with the following description:—

'If we accept the analogy between the vibrations of sound and the vibrations of a pendulum, we can understand that the latter can be made to give an equally faithful expression of the former, and also be made to register these expressions in a permanent manner.

'It will be easily understood that a pen or pencil connected with the vibrations of a pendulum and oscillating in the same plane—in which plane, also, the pencil is guided—would produce on a conveniently-disposed sheet of paper a straight line, but that at each succeeding vibration the length of the line would be diminished; furthermore, that the length of those lines and their successive diminution will depend upon,

and be influenced by, the lengths of the pendulum and the arcs of its vibration, though the time of each oscillation will be equal, again also influenced by the weight of the pendulum affecting the time that it will be kept in motion against the action of gravity and friction. Now, if, during the time the pencil or pen is describing the straight lines successively diminishing in length, we connect the pen with the movements of another pendulum either exactly similar or equally capable of being influenced by the various conditions stated, and not vibrating in the same plane, we can easily understand that the pencil will no longer follow its straight course, but comply with the compound motions arising from the pendulums vibrating in planes at different angles to each other. The resolution of these forces can be precisely predicted by the mathematician, and the result under similar conditions as to harmonic relations is a precise copy of the curves shown and produced on the screen by M. Lissajous, but with this difference, that the images formed by M. Lissajous are only seen by the portion of the image which the retina is able to retain, whilst the images formed by the vibrating pendulums give the whole course of the pen from the commencement of the vibrations to the end of them, and in which every phase of the interference of the pendulums with each other, every successive diminution of the curves arising from the diminishing arcs of vibration, and every node and loop of the vibration, is given with unerring fidelity, and the pen or pencil leaves permanent figures of great symmetry and beauty whenever the pendulums are beating in harmonic proportions, or nearly so.

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'The apparatus is composed of two parallel pieces of wood suitably supported at the height required; between these parallel pieces of wood the pendulums vibrate in planes at right angles to each other. The pendulums are hung upon two sharp points, and about four inches below the points of suspension the pendulum rods receive, within a recess or mortise formed in them, a small steel cross; the points of two arms of the cross are fitted vertically in the recess, the other two points are at right angles to these, and consequently horizontal; the two horizontal points support a light frame of wood, which projects in the direction of the plane of vibration of the pendulum; consequently these frames meet where the two planes of vibration meet, and at this point or apex the frames are connected by a ball and socket joint. It will be understood now that the steel crosses form universal joints, or Dr. Hook's joints, and that, connected as they are at the apex by the ball and socket joint, the apex of the frame will be influenced in its movements by either one pendulum or the other, or, if both are vibrating, will comply with the compound motion imparted to it—in fact, the equivalent of Lissajous' curves; a small cord supports the frame in a nearly horizontal position, and in the apex of the frame is fixed the graver, pencil, or glass pen, used to describe the curves.

'Beneath the pen is a small table, to which is attached the card upon which the tracing is to be made.

'The pendulums are each fitted with a weight which slides up and down the rods, and is fixed where desired by a set screw; loose weights as needed are placed upon this adjustable weight when greater weight is wanted.

'The apparatus thus described is the simplest form. Another form of the machine designed by Mr. Morgan Brown is supplied with longer pendulums, and having the upper part of the pendulum prolonged upwards for about twenty inches, this upper part in each case also being provided with a sliding weight, set screw, and loose weights for further addition. Each pendulum in this case is a compound pendulum, precisely like the pendulum of the well-known metronome, and has several important ad-

vantages over the common pendulum form, especially, as will be afterwards pointed out, when great differences in the proportions of the vibrations of each pendulum are needed.

'The machine is so simple in action that very few directions are required. A few hints may, however, save some waste of time; for if the pen is to describe a pleasing figure, the pendulums must be adjusted as carefully as a musical instrument to get it perfectly tuned.

'The pen being charged with ink, and the pendulums set vibrating, the pen is lowered steadily but quickly on to the card, and the pen at once begins to trace the curves. Two things are necessary to remember: the surface of the card must be large enough to prevent the pen in its curves passing over the edge, or the stroke of the pendulum not in excess, and the pen must not be brought down violently, or in either case the pen will surely be broken.

'Never attempt a curve with the pen until you have the pendulums beating in the proportions required, or you will frequently have nothing but a scribbling machine. A very little practice will soon enable the observer to count the proportions; for instance, if unison be desired, bring both pendulums to the meeting angle, and let both escape together; a few vibrations will soon show which arrives at the starting-point in advance of the other, and indicate the adjustment to be made accordingly. It is scarcely necessary to repeat the well-known truism about a clock pendulum—shorten it to make it faster, and lengthen it to make it slower. With the proportions one to three, count only the three, each recurring time of three; the eye will at once detect which pendulum is in advance or retrogression, and needs adjusting. For rough adjustment you may count the vibrations per minute; but the plan described is the most accurate for careful adjustment, and much quicker.

'The diagrams of curves given are simply the skeleton optical forms of a few harmonic vibrations, which the pen will fill up with gradually decreasing concentric forms till the pendulums come to rest; many other harmonic vibrations will give equally or even more beautiful figures.

'Although there are apparently but few initial forms, the varieties are almost endless, and depend upon these conditions and variations.

'Firstly—vibrations of the pendulums caused by their difference of length. For the common pendulum machine, the following approximate lengths of pendulums with proportionate vibrations to the seconds pendulum, in the latitude of London, may be useful for reference:—

Proportions	Vibrations per Minute	Lengths in Inches
1 : 3	60 : 180	39·1 : 4·3
2 : 5	60 : 150	39·1 : 6·2
1 : 2	60 : 120	39·1 : 9·7
3 : 5	60 : 100	39·1 : 14·0
2 : 3	60 : 90	39·1 : 17·3
3 : 4	60 : 80	39·1 : 21·7

'The figures of the higher proportions here are not easy to get with the common pendulum, because the arcs of vibration decrease so rapidly in the quick pendulum. With the compound, or metronome, pendulums, there is no difficulty in obtaining very much higher proportions, and for this reason—with the common pendulum it is inconvenient to extend the pendulum even to 39 in.; the limit of least number of vibrations, which is 60, is much too high a factor to start with when it has to be multiplied by 3, as in the case of 1 : 3; consequently the second pendulum must be 4 in., a length impossible to work with. In the metronome pendulums of even greater length, there is no difficulty in setting them to vibrate to 20 or even less; and with 20 as a factor, we get for the proportion, as before, 1 : 3, equal for the second pendulum 60 vibrations, or the full length of the slow pendulum in the simple arrangement.

'In the simple pendulum apparatus, short pendulums must be used for the higher numbers, and hence the disadvantage of having to provide more than two pendulums; whereas in the metronome pendulums two are sufficient for nearly all combinations.

'Secondly—difference in the length of the stroke of the pen by the difference of the arc of vibration of the pendulum. Great variety may be given to the figures by the change of proportions in the stroke of each pendulum or their arcs of vibration.

'Thirdly—greater or less weight on the pendulum rods, influencing the time during which the vibrations continue, and consequently the closeness with which the lines of the drawing approach to or recede from each other. The lighter the weights attached to the pendulums the more rapidly they come to rest, and thus in finer or coarser figures we have again the means of varying the character of the drawings. This

difference can also be easily caused by weighting the pen in its passage over the paper; the friction tells at once on the arcs of vibration.

'Fourthly—phase of difference practically obtained by the relative starting-points of the arcs of vibration to each other. This is the most difficult of all, and nothing but practice can enable the operator to achieve the precise form desired. Having set the pendulums to vibrate truly to the proportions required, one must be started first, and the other pendulum must be started with it, or at such intervals of the vibration as the diagrams show. In calculating the interval at which the second pendulum is allowed to start on its course after the first one, allowance must be made for the one being in motion and the other starting from a position of rest. With the pendulums vibrating truly, every curve will be beautiful, and in the chapter of accidents the operator will get every form; but, with the few directions we have given and patience, he will soon acquire the skill to produce any initial form he may desire.

'When the operator has learned how to manipulate the machine, he has but one thing to remember—that the pendulums must beat in nearly or quite harmonic proportions; then every phase of difference will give him varieties of those proportions and forms of beautiful curves almost as numerous as the combinations of the musical tones themselves.'

This sympalmograph, and all the required accompaniment, can be obtained from John Browning, of 63 Strand, London.

SYMPIESOMETER. A modified form of the barometer for use at sea. This instrument consists of a syphon tube containing a volume of air and a fixed fluid, which partly fills the tube; also a thermometer. By an increase or decrease of the weight of the atmosphere, the fluid is raised or lowered, arising from the elasticity of the enclosed air, according to Mariotte or Boyle's law, through equal distances for each barometric inch, if the confined air were unaffected by varying heats, but as it is affected by temperature this error is allowed for by a temperature scale. To take a reading the thermometer must be first recorded, then the attached pointer must be adjusted to the corresponding degree of temperature on the syphon tube—then the position of the fluid indicates the barometric height.

SZMIKITE. A sulphate of manganese found at Felsöbanya, Transylvania, and named after Mr. Szmik, Counsellor of Mines. The colour of the nodules is whitish, the fracture reddish-white. Analysis gives—

Sulphuric acid	47·43
Oxide of manganese	41·78
Water	10·92
	100·13

—T. von Schroeckinger. *Imp. Geo. Instit. Vienna*, April 1877.

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TALLOW AND STEARINE. (Tallow, vol. iii. p. 967.) Our importations in 1875 and 1876 were—

From	1875		1876	
	Cwt.	£	Cwt.	£
Russia	50,617	128,068	95,122	198,578
Holland	3,749	11,245	3,010	8,479
Belgium	11,801	29,624	10,000	26,257
France	23,357	68,335	10.218	26,209
United States of America	260,754	768,317	576,609	1,244,512
Mexico	—	—	6,040	12,052
Peru	10,713	19,600	—	—
New Granada	—	—	5,240	10,480
Brazil	—	—	7,344	16,730
Uruguay	104,315	222,471	93,904	195,101
Argentine Republic	110,978	239,605	253,633	540,799
Australia	270,408	623,695	267,932	646,762
Other countries	20,684	44,007	23,793	47,832
Total	967,396	2,045,863	1,344,445	2,875,171

TAMARIND, WILD. See Mimosa Seed.

TANGERRY-VERRY. A dye-drug used in India. See Cassia Tora.

TANNING. (Vol. iii. p. 83.) (*Passer en tan*, Fr.; *Gerben*, Ger.) The favourable action of soda when added to lime in preparing the skins of animals for tanning has been long recognised, and the presence of sulphur has been admitted to be advantageous.

M. Louis Mathern, of Antwerp, exhibited at Vienna in 1872 a new depilatory liquor, which consisted of slaked lime, soda, and sulphur. Eitner in 1873 treated the skins of calves, horses, and bullocks with a similar liquor, and finding that the mixture was the more effective the more sulphide of sodium it contained, he resolved upon using this substance exclusively. Obtaining perfectly pure sulphide, he found that bullocks' skins were depilated in 15 hours, and calf skins in 4 hours.

The following constitutes the depilatory operation:—The skins are spread out flat upon each other on their flesh side, and then painted with sulphide of sodium over the hair in such a manner that it touches the skin. After this is done the skins are folded together, put in a warm place, not below 19° C., and covered with a wet rug to prevent them from drying. The skins are ready for depilation in about 15 hours.

The solution is prepared by dissolving a weighed quantity of crystallised sulphide of sodium in hot water, using 1 kilo. of the salt and 2 litres of water. This solution must be thickened with lime, using 3 parts to 1 of sulphide of sodium. The quantity of sulphide of sodium required in depilating the skin of a bullock varies, according to the size of the skin and quantity of hair, between 100 and 120 grams. Dried skins require 17 to 35 grams more salt. The solution must be applied to every part of the skin, more especially to the head and along the back, and it is necessary to remove any stones or coarse sand from the lime, which would prevent the solution from acting. The skins should be quite soft before treatment, and if dirty on the hair side they should be well cleaned. Before removing the hair the skins should be washed in water to get rid of the caustic depilatory.

When the hair has been removed the skins are placed in fresh and hard water, partly to wash them and partly to swell them, because without this the fleshing would be rendered very difficult. The leather clippings are the same as those obtained from sweated skins, and must be treated with lime before boiling them for glue. After the fleshing the skins are treated in the usual manner, and tanned like sweated skins.

The use of sulphide of sodium was not so successful in the manufacture of the second class of under-leather.

The main part of the tanning of such leather is not entirely effected in the pit, where the acids are formed, and which, next to tannin, are the most important agents in the preparation of under-leather; but a preparatory tanning already takes place in the ooze, which latter represents the principal feature in the manufacture of upper-leather.

In tanning sole-leathers the outside of the skin is only coloured in the ooze, and the dead and shrivelled fibre is swelled by the acids; and in this state, by the action of acid and tannin on the natural fibre, it is converted in the pit into leather.

Inner sole-leathers, which were formerly treated with lime, do not at first require acids for the swelling, but so much the more tannin to prevent them from being spoiled. This tannin enters into the leather with comparative quickness, because it is absorbed much better in the ooze than in the pit, and because the lime, which dissolves and removes many portions of the skin, thus leads the way into the inside of the skin. These leathers, therefore, contain more tannin and less acid than sole-leathers. Skins depilated with sulphide of sodium, as already mentioned, completely resemble those of sweated skins, but differ from limed skins; the former, therefore, in their first period of tanning require another treatment.

Skins depilated with sulphide of sodium are less swelled than limed skins, therefore the oozes in which these skins are to be tanned must contain more acid than lime-oozes. The reason why the tanning is slower, and a larger quantity of tan has to be used, is the following: in the first place, these skins contain more material to be tanned, for nothing has been taken out; and secondly, their texture is very firm and close, whereas lime loosens and partly destroys it.

Skins treated with sulphide of sodium are said to have 10·4 per cent. more weight than limed skins.

It seems probable that lime will soon be superseded by sulphide of sodium, because the first operations are quicker, and also because a better quality of leather is obtained.

Tanners have hitherto been of opinion that skins treated with lime give leather of greater firmness and softness. Eitner admits this, but states that lime removes valuable substances from the skins, which sulphide of sodium will not do, and he

recommends the following method:—The skins are soaked, carefully stretched, and if possible fulled; they are then treated with a mixture of 1 part of sulphide of sodium and 3 parts of slaked lime. The quantity of sulphide required for each skin depends on the quality and size of the skin, on the quality of the sulphide of sodium, on the degree of softness, also on the quality of the lime, and on the hardness of the water used, as a portion of the sulphide of sodium is fixed by the constituents of hard water, and is thus rendered ineffective.

It is easy to see that exact numbers cannot be given for all cases, but under normal conditions, i.e. a medium article in strength, size, and softness, medium hard water (10° to 20° of hardness), pure lime, good and new sulphide of sodium would be required for a piece of—

Green bullock's-skin	105 to 175 grams.
Dry "	123 " 193 "
Dry kips	88 " 123 "
Dry calf-skin	35 " 53 "

The solutions must be only slightly acid, and the number of tans used must never be below eight. By adding 250 to 600 grams of bicarbonate of soda the solutions will be kept neutral, or we may add ½ to 1 kilo. of salt, which, in spite of the acid, will prevent the leather from becoming too hard.

After the upper-leathers have been scraped and shaved, they should be well cleaned, and for this purpose a solution is used of 5 kilos. of oat straw, boiled in 110 litres of water. After being soaked in this liquid the skins are ready for tanning.

The use of sulphide of sodium is very essential in the manufacture of deer and kip-leather; and in treating skins where arsenic has to be used, sulphide of sodium will be found less expensive and not so dangerous. For very hard skins twice the usual quantity of sulphide of sodium may be used; in the manufacture of horse-leather, pig skins, and morocco it has been found very successful.

Much depends on the quality of the sulphide of sodium used; it should be in a tolerably pure state, and the less damp and the more bright and transparent it is, the better will be the quality. The amount of acting substance is found to vary considerably, a difference of 30 per cent. having been found sometimes. This is partly due to decomposition and changes of the salt, and partly to difference in its manufacture. It is very necessary to keep the sulphide of sodium dry in well-closed vessels, and it should be used as quickly as possible, as it will not bear keeping. Eitner says the sulphide may be prepared for experiments in the following manner:—

Three kilos. of lime are placed in an iron vessel and slacked, after this 55 litres of water, and 6 litres of cyst soda are added, and the mixture heated and agitated.

As soon as the boiling commences, 1 kilo. of flowers of sulphur is gradually added, and the whole boiled until the liquid assumes a deep golden-yellow colour, and shows no lumps of sulphur. The mixture is then allowed to cool, and may eventually be thickened with lime and directly used for working. (See Leather.)

TANNOMETER. A piece of apparatus for determining the quantity of tannin in a solution. (See Leather.)

TANTALUM, NIOBIUM or COLUMBIUM. (Vol. iii. p. 969). J. Lawrence Smith, in a paper on the 'Columbic Acid Minerals,' maintains that the metal known in England and on the Continent as Niobium should be called Columbium, the name used in America. The confusion is said to have originated as follows: Ekeberg discovered in 1802 a supposed new metal, which he called tantalum, but which a short time afterwards was regarded as identical with columbium; and for forty-five years tantalum and columbium were synonymous terms in all works on chemistry, although Wollaston suspected their dissimilarity. Secondly, when H. Rose made his well-known exhaustive researches on the columbite of Bodenmais, he showed that this mineral contained, not one, but two metallic acids. One of these was *tantalum*; but the other he supposed to be a new metal, which he named *niobium*. Subsequent examination, however, convinced Rose that the two metallic acids obtained from the Bodenmais columbite were really the original columbic acid of Hatchett, discovered in 1801, and the tantalic acid discovered by Ekeberg in 1802. The former body, therefore, should have retained its original name. The remainder of the paper is devoted to the examination of the columbic minerals, columbite, microlite, pyrochlore, Hatchettolite, samarskite, yttrotantalite, euxenite, Fergusonite, and Rogersite.

TAR. (Vol. iii. p. 970.) The use of coal tar has largely increased of late years, and notwithstanding the value of this product in the manufacture of colours, a considerable quantity is used for preserving wood and similar purposes. Our importations of wood tar were in 1875 and 1876:—

From	1875		1876	
	Barrels	£	Barrels	£
Russia	120,600	117,744	120,059	108,583
Sweden	9,017	12,695	7,934	8,419
Germany	12,247	12,842	10,269	11,104
United States of America . . .	14,569	13,665	23,297	19,652
Other Countries	16,296	8,905	8,478	5,211
	173,666	165,351	170,037	152,969

In 1877 we imported 174,600 barrels, valued at 146,876*l.*

TASMANITE. (Vol. iii. p. 972; and Dysodile, vol. ii. p. 178.) Under dysodile it is shown by Prof. A. H. Church that the two minerals, dysodile and tasmanite, do not belong to the same group (October, 1876).

TEA. (Vol. iii. p. 972.) The following inquiry was made by G. W. Wigner:—

Moisture and Hygroscopic Properties of Teas, dried at 100°, and then exposed in the Investigator's Laboratory for parts of February and March.

	Description	Water	Weight of 100 grains Dried at 100°	Weight after Exposure to Air for		Weight gained by Exposure
				4 days	11 days	
1	Indian Young Hyson .	5·68	94·32	97·57	100·88	6·56
2	Moyune " " .	4·84	95·16	98·92	101·25	6·09
3	Gunpowder . . .	4·94	95·06	100·68	101·10	6·04
4	Moyune Gunpowder .	5·16	94·84	98·54	101·31	6·47
5	Do. do. .	5·70	94·30	98·22	100·50	6·20
6	Do. do. .	6·18	93·82	97·83	100·77	6·95
7	Do. do. .	6·55	93·45	97·42	100·43	6·98
8	Medium Oolong, 1874 .	6·30	93·70	99·85	100·22	6·52
9	Oolong	6·77	93·23	97·88	100·89	7·66
10	Manonino, Fine . .	7·09	92·91	98·42	98·90	5·99
11	Broken Indian . .	7·30	92·70	97·43	100·24	7·54
12	Fine Kaisow . . .	8·00	91·40	98·48	98·59	7·19
13	Kaisow, 1870 . .	10·52	89·48	96·26	96·66	7·18
14	Do.	10·80	89·20	96·79	96·67	7·47
15	Orange Pekoe . .	5·58	94·42	98·45	101·22	6·80
16	Indian " . . .	6·87	93·13	99·49	99·93	6·80
17	Scented Orange Pekoe .	7·79	92·21	98·19	98·32	6·11
18	So Pekoe, 1869 . .	9·39	90·61	96·64	97·29	6·68
19	Pekoe Siftings . .	9·45	90·55	96·81	96·80	6·25
20	*Consolidated* . . .	8·11	91·89	96·58	99·14	7·25
21	Indian Souchong . .	8·16	91·84	98·14	98·45	6·62
22	Caper	6·80	93·20	98·80	99·00	5·80
23	Do.	7·00	93·00	98·90	99·00	6·00
24	Do.	8·00	92·00	98·60	98·90	6·90
25	Do.	8·00	92·00	99·00	98·90	6·90
26	Do. 1872 . .	8·52	91·48	98·26	98·47	6·99
27	Indian Congou . .	6·56	93·44	98·41	101·75	8·31
28	Congou	7·28	92·72	97·25	100·08	7·36
29	"	8·06	91·94	96·41	99·68	7·74
30	Moning Congou . .	8·49	91·51	99·00	99·09	7·58
31	Do. do. . .	8·64	91·36	96·71	99·78	8·42
32	New District . . .	9·08	90·92	98·76	97·97	7·05
33	Moning	9·17	90·83	98·50	98·21	7·38
34	Congou, 1869 . .	10·04	89·96	96·67	98·87	6·91
35	Do.	10·33	89·67	96·65	96·62	6·95
	Mean . . .	7·67	—	—	—	6·95

Amount of Extract yielded by Twenty-four Genuine Teas.
Ordinary Teas.

Description	Extract	Ash of Extract
Gunpowder	39·20	5·75
Hyson	36·80	5·00
Congou	33·00	4·75
Do.	29·80	—
Do.	29·80	4·45
Do.	26·20	4·00
Do.	26·15	—
Special Teas		
[1] 2. Moyune Young Hyson	44·55	7·00
1. Indian Young Hyson	43·85	5·80
11. Broken Indian	43·43	6·13
4. Moyune Gunpowder	40·75	5·45
Oolong	40·75	—
Moyune Gunpowder	39·30	4·80
6. Do. do.	38·50	4·90
5. Do. do.	37·95	5·25
10. Mannuna, Fine	37·00	6·00
17. Scented Orange Pekoe	34·20	5·40
7. Moyune Gunpowder	33·35	4·95
Assam	33·30	6·65
21. Indian Souchong	32·50	5·50
Capers.		
Caper	37·90	4·70
Do.	37·75	5·15
Do.	32·40	5·25
Do.	30·05	4·70

Tannin.—The percentage of tannin in tea is very variable, and some teas exceed the average so greatly that, as regards adulteration or impurity, the tannin determination can give only negative results:—

Moyune Young Hyson	30·0	per cent.
Very choice Assam	33·0	"
Indian Young Hyson	30·0	"
Assam from Dr. Macnamara's garden	37·7	"
Caper, mixed	42·3	"
Mixture of six samples of Assam	45·5	"

Total Nitrogen in Tea

Sample from 60 green teas *slightly faced*	3·76	per cent.
" 60 black teas	3·20	"
" 6 Assam teas	3·64	"
" 6 Caper teas	3·32	"
Sample Assam from Dr. Macnamara's garden	3·88	"
Exhausted leaves	3·60	"

Partial analysis of a mixed sample of twenty-four genuine black teas, and of a mixed sample of a medium quality (*faced*) green tea:—

	Black	Green	
Potash	30·02	28·42	per cent.
Soda	1·68	2·08	"
Sulphuric acid	4·88	5·66	"
Carbonic acid	11·60	5·43	"
Silica	1·70	7·50	"
Ash soluble in water	57·00	52·85	"

G. W. Wigner, *Pharm. J. Trans.* (3) vi., abstracted from the *Journal of the Chemical Society*, March 1876.

Tea, Ceylon.—Dr. Thwaites, in his annual Reports on the Botanic Garden at Peradeniya, gives full accounts of the progress of the cultivation of the tea plant in Ceylon. He states that in 1864 some gentlemen who visited Ceylon, thinking the climate would prove congenial, obtained seeds of the tea plant, and these plants were

[1] These numbers correspond with those in the previous table.

raised in the Botanic Garden, and distributed. In 1865, Dr. Thwaites reports:—The climate of Ceylon is admirably adapted for the successful cultivation of tea. The plant grows well from the elevation of Peradeniya—1,600 feet—to that of Hakgalle (5,000), and it would no doubt thrive in situations somewhat higher. A certain number of plants were planted out at Hakgalle, and a larger number of plants were raised in the Botanic Garden. A year later the cultivation had become much more decided, and a report of progress by an experienced Indian planter was made to the Government.

In 1869, young plants of the Assam hybrid variety, raised from seed, were growing vigorously at Hakgalle, in a small plantation which had been formed, and which contained 270 plants. All the varieties of tea are reported to succeed better at Hakgalle than at Peradeniya; the China tea being the only one which grows at all well at the lower elevation.

In 1870, Dr. Thwaites says:—'The tea plant thrives so luxuriantly upon our hills at an elevation slightly above that suited for coffee cultivation, that it is difficult not to believe that our slopes will before very long be covered with thriving tea plantations.' In 1871 and 1872 the reports were most favourable. In 1875, Dr. Thwaites writes: 'It is now a well-established fact that commercial tea of a very superior quality indeed can be produced in Ceylon.'

Tea, Indian. In the list of our imports from British India tea is distinguished by the large increase shown in the returns for the year 1875. The quantity rose from less than 18 million pounds in 1874 to upwards of 25 millions in 1875, and the value advanced to nearly 2,200,000*l.*, giving tea a place among the articles for which we pay India more than two millions sterling in the year. The Indian Government report on the financial year 1874–75 states that the cultivation of tea is rapidly spreading in Bengal, and that the amount of the out-turn is now amply remunerative; the prices obtained in the market are such as show that the average quality is good, and, indeed, the industry is in an infinitely better and safer position than it was ten years ago. The native labourers are well treated by the European planters, and are generally contented. The best labourers come from Nepaul, and bear a good character for industry and aptitude. In the Darjeeling district the increase of area under tea cultivation in the year was 3,193 acres, and the increase of out-turn was 971,201 lb. The average yield of an acre was about 325 lb.; in 1872 it was about 256lb. The tea plant was introduced on the Neilgherry Hills about forty years ago, and now covers nearly 2,000 acres. The China variety, with which the oldest of these estates is planted, is the most hardy, but grows slowly, and produces very little leaf; the Assam variety, on the other hand, grows rapidly, and is a large producer of leaf, but it requires a sheltered situation on a rich, fertile soil. The cross between the two is the most generally useful.

Importation of Tea into the United Kingdom in 1875 *and* 1876 (*6d. per lb. duty was fixed June* 1, 1865).

From	1875		1876	
	Lb.	£	Lb.	£
Holland . . .	1,102,601	82,475	1,451,244	96,822
China	170,402,921	11,461,840	155,907,582	10,145,471
Japan	54,806	3,726	80,448	4,690
United States of America	123,678	9,670	100,251	8,545
British India—				
Bombay and Scinde .	246,692	16,161	327,957	21,176
Madras . . .	124,615	7,842	99,730	9,326
Bengal and Burmah .	25,056,357	2,163,850	27,356,518	2,398,104
Ceylon . . .	159,602	12,003	91,887	6,590
Other Countries . .	173,051	13,250	90,946	6,671
Total . .	197,505,316	13,760,901	185,536,371	12,097,204

In 1877 we imported from China 163,879,763 lb., from British India 31,246,251 lb., and from other countries 1,604,959 lb., the total value of which was 12,482,409*l.*

TEEL OIL. See Sesamum.

TEETH. Elephants', sea-cow, and sea-horse teeth imported in 1875 and 1876, from the 'Annual Statement of the Trade of the United Kingdom with Foreign Countries and British Possessions.' As no returns of ivory are given, we suppose ivory of all kinds is included in the teeth:—

From	1878		1879	
	Cwt.	£	Cwt.	£
Germany . . .	506	19,626	428	15,904
Holland . . .	253	12,755	469	21,800
Egypt	2,411	113,454	695	29,805
Tripoli and Tunis .	400	20,640	425	22,639
West Coast of Africa—				
Portuguese Possessions	312	14,186	278	12,776
Not designated . .	2,207	109,582	2,574	125,164
East Coast of Africa .	696	39,678	424	24,768
United States of America	390	10,611	—	—
Malta	536	25,701	691	23,010
Gold Coast . . .	251	11,620	163	7,109
British Possessions in South Africa . .	1,442	67,016	1,722	69,202
Aden	2,508	131,358	1,628	84,253
British East Indies .	3,575	171,917	2,548	124,910
Other Countries . .	681	24,321	600	20,817
Total . .	16,258	772,871	12,538	685,762

TEINTE DE FISMES is made by digesting 500 parts of elder-berries with 60 parts of alum in 800 parts of water, and then submitting the mixture to pressure. This is used for adulterating wine. M. Maumené reports that he has discovered as much as from four to seven grams of alum per litre in wines adulterated with this fluid. Sometimes the alum is replaced by tartaric acid. See Wines, Adulteration of.

TELEDYNAMIC CABLE. 'Teledynamic cable' is the name applied by L. Vigreux to the endless wire rope as used for the transmission of power from one shaft to another. He defines his problem by supposing that a shaft, A, receives from one or more prime movers an energy equal to 60 h.p., and has to transmit this to another shaft, B, which latter is at a horizontal distance of 875 yards, on a level 13 feet higher, and is inclined to A at an angle of 10°. In certain cases B also receives energy from a steam-engine of 20 effective h.p., whose main shaft makes 60 revolutions per minute, is 26 feet distant from B, and transmits its power by a pair of pulleys and a leather belt. The transmission between A and B is effected by a wire rope passing over intermediate sheaves; and the problem is to calculate the work lost by friction, &c., in this transmission, and to compare its effect with that of a line of shafting and two pairs of bevel wheels, which would be the alternative method.—L. Vigreux, *On the Transmission of Motion by 'Teledynamic Cable,' and by Belt and Pulley.* (*Annales du Génie Civil*, 2nd series, vol. v., pp. 171, 233, 314.) *Abstracts of Papers in Foreign Transactions*, Institution of Civil Engineers.

TELEPHONE. The name given to an instrument for conveying sounds (strictly through the agency of an electric current) to a distance.

The first attempts to effect this appear to have been made by Mr. Page, a well-known man of science in America, in 1837. He discovered that when a current passing through an electro-magnet was made and broken, the magnet emitted sounds, and he succeeded in producing thus musical notes. In 1843, De la Rive found that if a pianoforte wire, four feet in length, were stretched through a cylinder of clothed copper wire, and a rapid succession of currents were transmitted, the wire vibrated, and gave musical sounds.

In 1861 Philip Reiss took up this inquiry. He noticed that the vibrations of a tuning-fork—if employed in making and breaking an electrical current—will produce pulsations in the current, which will alternately magnetise and demagnetise soft iron at the remote end of a circuit, and that similar vibrations could be set up in another tuning-fork at a considerable distance. Upon this principle Reiss constructed the first 'telephone.'

In this the sending instrument consisted chiefly of a membrane stretched over a box in such a way that the membrane was put in vibration by the voice of anyone speaking into the box. On the membrane was a piece of platinum, which, as it moved to and fro, formed and broke the electrical connection in a properly arranged line of wire. By this time the electrical pulsations were transmitted to a coil of wire surrounding an iron bar, this having the curious effect of causing the bar slightly to expand and contract at each pulsation. These slight alterations in length, rapidly succeeding each other, produced a musical note, which corresponded in the number of vibrations with that sounded in the box, and was, therefore, identical with it. But

though the note is the same, it is not of the same quality. The instrument cannot reproduce that; it merely sings with its natural note.

This will be understood more thoroughly by attention to the following diagram (*fig.* 2549):—

2549

b is a hollow wooden box, into which the operator sings through the mouthpiece, *a*. The undulations produced by the voice of the operator throws the diaphragm, *c*, into rapid vibrations, so as to make and break contact with the platinum points, *d*, at each vibration. This interrupts the current flowing from the batteries, *e*, as often as the diaphragm vibrates, and therefore magnetises and demagnetises the electro-magnet as often. Whatever note is sounded into the box, *a*, will occasion the diaphragm, *c*, to vibrate, and the electro-magnet, *f*, will vibrate in unison, and repeat the note.

Mr. Cromwell Varley, in 1870, discovered that if a pulsating electric current of high tension is sent through a 'condenser,' which is an arrangement of thin plates of alternately conducting and non-conducting materials, the plates will vibrate, and, if of proper construction, will produce a musical note. The condenser, according to Mr. Varley's patent specification, is made as follows:—

Very thin uniform paper dipped in shellac varnish is coated on one side with gold leaf, and dried. The non-gilt surfaces of two sheets are put together so as to leave the gilt surfaces outside; tinfoil plates are placed outside, and the sheets are built up in the usual manner, connecting the 1st, 3rd, 5th, and so on, to one armature of the condenser, and the 2nd, 4th, 6th, and so on, to the other armature. If then the rapid alternations of current be made to pass round a helix containing an iron rod, the latter will produce a feeble but distinct sound. If the currents pass round a flat coil in which a magnetised harmonium tongue is placed, they act upon it as if it were the needle of a galvanometer, and cause it to vibrate. Similarly, if a steel tongue is so placed that its tip is between the poles of a powerful permanent magnet, the alternating currents will cause it to vibrate and produce a musical sound while the alternating currents pass. Other methods of producing the required vibrations are described, and in particular a wire 4 ft. 6 in. in length is specially mentioned, and the method of arranging it fully explained, as if that were the sound-producer. Mr. C. Varley does not appear to have thought of producing a number of sounds of varying pitch; and, as a matter of fact, he claims only the sending of wave-signals as well as current-signals simultaneously on the same line wire, and the construction of telegraphs with, at the transmitting station, an instrument capable of setting up a succession of rapid and regular electric waves, and at the receiving station a strained wire or tongue, or such-like instrument, adjusted to vibrate in unison with the electric waves. He also claims the method of dividing a conducting wire into sections by instruments to which he gives the name 'echocyme,' which allow current-signals to pass freely, but stop wave-signals; so that while the wire is being used as a whole for the transmission of current-signals, the sections into which it is divided may be used for the local messages. The construction of a telegraph with, at the sending end, an instrument capable of originating a succession of rapid electric waves, and at the receiving end a condenser consisting of thin sheets capable of being agitated by such waves, forms one of the claims; and Mr. Varley also claims the combination with Gintl's double-speaking apparatus of a hollow helix with rods or pieces of iron inserted; but he does not mention a sending instrument consisting of a number of tuning-forks, nor does he speak of reproducing a series of musical sounds.

By some modification of this arrangement Mr. C. Varley reproduces electrical waves, as sound-waves of sufficient intensity to be heard at some distance from the instrument. The apparatus exhibited by him at the Queen's Theatre (November, 1877) consisted of a large tambourine, and the condenser already described was placed close to it. The plates or leaves of the condenser are driven apart and brought

together by the pulsating electric current, producing thus a number of sound-waves, which act upon the membrane of the drum-head and produce musical sounds of a more or less pleasing quality, and of sufficient intensity to be heard at any part of such a space as the auditorium of a theatre. The notes resembled those of the hautboy, or bassoon, but the majority resembled the early efforts of a tyro with the flute. A series of twelve tuning-forks, ranging from C below the staff to G above, were employed for obtaining the musical vibrations, but whether some of these required adjusting, or the condenser was incapable of taking up only certain rates of vibration, and reproducing them as musical tones, we cannot determine.

Powerful notes were given out at intervals, quite sufficient to show that a little further investigation must lead to the production of an instrument of considerable capability. The reproduction of an air is a success yet to be achieved by this instrument.

As it is desirable that a record of all that has been accomplished in the process of this inquiry, the *Revue Industrielle* (1877, p. 168) says:—

'For several years inventors have endeavoured to solve the problem of transmitting to a distance articulate and musical sounds. Some of Wheatstone's earlier experiments, on the figurative signs produced by sounds, have led others to more successful results. In 1860, Reiss of Friedrichsdorf, following the labours of Wertheim, Marian, and Henry, invented the telephone bearing his name. This instrument is in two chief parts—a transmitting and a receiving instrument. The first is constructed with a stretched membrane, which, vibrating in unison with the waves communicated by musical sounds produced in its neighbourhood, transforms them into a series of electric currents by a simple contact apparatus. The receiver is constructed upon the principle that a distinct sound accompanies the demagnetisation of a bar of soft iron placed in the interior of an electro-magnet. The intensity of this sound is increased by resonant boxes, a note of, say, a hundred vibrations being produced in the neighbourhood of the transmitting apparatus. The membrane makes 100 vibrations, and establishes and completes the circuit of the electric current 100 times, giving the same number of demagnetisations in the receiver, the bar of which thus produces the corresponding note.'

The 'Harmonic Telegraph,' which appears to have been first introduced by Elisha Gray, of Chicago, by which musical notes are clearly transmitted, is thus described:—

The patentee divides his invention into three parts. The object of the first part of the invention is to insure the transmission of tones of uniform amplitude of wave, whether a greater or less number of tones be transmitted simultaneously, which end is attained by combining each musical tone-transmitter with its respective section of the main battery, by a short or shunt circuit, in such manner that each section is utilised for the transmission of the vibrations of its own tone without interfering or drawing upon the other sections of the battery or opening the main circuit; and, when not transmitting, the unemployed sections of the battery flow steadily to line, without affecting the working transmitters of the other sections. This part of the invention thus possesses two distinguishing characteristics. First, that of a main circuit always closed; and second, the passage through this circuit of a smooth current, so to speak, when all the transmitters are quiescent, each transmitter when in operation throwing its respective portion of said current into vibration, so that there may be a smooth current and one or more vibratory waves simultaneously transmitted through the circuit, or the entire current may be thrown into vibration.

The object of the second part of the invention is to dispense with local batteries and all adjustment at the receiving end of the line, which end is attained by means of an apparatus consisting of a tuned bar or reed suitably attached to an electro-magnet, and the whole mounted upon a resonant box closed at one end, the cavity of which is tuned to the same fundamental as that of the aforesaid reed or bar, which apparatus analyses composite tones transmitted electrically through a wire, whereby the operator is enabled to read directly from the tone transmitted.

The object of the third part of the invention is to furnish an attachment to the analysing apparatus, whereby the vibrations of the air column within the resonant cavity are made to produce a corresponding vibration in a diaphragm suitably mounted in front of said cavity, which vibrations are communicated to a spring or bar operating a local circuit, which local circuit may be attached to any of the various forms of telegraphic recording instruments.

Each battery is connected with its respective transmitter by a short circuit or shunt wire. Each battery is divided into sections 1, 2, 3, 4, 5, 6, not by separating or disconnecting its cells, but by throwing a short circuit or shunt wire around each section. Each shunt wire runs through its own key and vibrating transmitter: for instance, a wire passes in section 1 of battery 1, which is at the line end of the battery; a wire passes from the negative (−) pole of the battery to one binding screw of the transmitter, at which point the circuit divides, one branch connecting to line and the other to the

vibrating bar of the transmitter through the break-point, which is in this instance a shunting point. The circuit then passes to the other binding screw, and thence to the key lever. The anvil or lower point of the key is connected directly with the ends of a wire, which forms the dividing line between sections 1 and 2, forming part of the short circuit of each section, and so on.

Now, if the reed or bar of transmitter be vibrated by its local battery, and the key belonging to and in the same circuit with it be depressed, the shunt circuit around section 1 will be completed every time the vibrating bar or reed makes contact with its break point, thus producing a set of waves or electrical vibrations throughout the line, the waves succeeding each other at the rate per second corresponding to the vibrations of the transmitting reed or bar, which waves will induce corresponding impulses in all the magnets of the power approximating one-sixth of the whole battery. Although these magnetic impulses are induced in all the magnets in the circuit, one only will make an audible response except to a very delicate test, which one in this instance will be the receiver whose reed or bar is tuned correspondingly to the transmitter in operation. All the other sections of the apparatus are connected up and operated in a manner precisely similar, each operating on its own section of battery. Each transmitter differs in pitch, and has its complement in its own corresponding receiver. By working with this system the main circuit is never opened, owing to the fact that the integrity of each set of waves is preserved intact, thus rendering an analysis easy at the receiving end of the line.

The vibrating tongue-reed of steel is fastened to a support and united with one pole of a magnet. The free end of the reed passes close to, but does not touch the other pole of the magnet. The resonance box is constructed to produce the maximum resonance of the desired tone, and the reed is accurately tuned to correspond. Thus, as the reed vibrates, the sound of its fundamental tone is intensified by the resonance of the box. If an electro-magnet be connected in a telegraph circuit, and a note be transmitted by one of the transmitters, the note will sound in the box, provided the tone transmitted corresponds with that of the box. Should a second analyser be similarly placed in circuit, and tuned to a different pitch, and a second note of corresponding pitch be transmitted, it will sound in the box of corresponding pitch, without affecting the other. As many as eight different tones simultaneously transmitted through a single wire have been thus analysed and reproduced. That musical sounds should be transmitted by telegraph is less remarkable than it first appears. We have only to consider the conditions of the problem. Sound is, of course, the result of air vibrations. If it be possible to reproduce at any place an exactly similar series of vibrations to that occurring at any other place, the same sounds will be heard at both spots. The vibrations must obviously be precisely similar—of the same rapidity, to give the tone or pitch; of the same amplitude, to give the intensity or volume of sound; and, more difficult to explain, they must also be such as to give the quality, which HELMHOLTZ has shown to depend on the 'harmonics' accompanying the primary tone.

It is not difficult to say that the vibrations of a tuning-fork, making and breaking an electrical circuit, will produce pulsations in the current, which can, by their action on a magnet, alternately magnetised and demagnetised at each interruption and formation of the circuit, produce exactly similar vibrations in another tuning-fork, through a long circuit having similar forks at its end.

On November 28, 1877, Professor A. GRAHAM BELL, the patentee and inventor of the telephone, which is now attracting universal attention, delivered a lecture at the rooms of the Society of Arts, and this paper has been published in the Journal of that Society. It is important to preserve the inventor's own words, and we copy, so far as is consistent with the difference between an address in public and a permanent record, Professor GRAHAM BELL's paper, omitting, however, a few speculations which relate rather to the future than to the present:—

'Telephony is receiving at the present time a great deal of attention from men of science all over the world, and it is my intention to try and give you a short account of the means by which sound can be produced at a distance by electrical means. There are probably many here present who may recollect the early telephonic experiments made in this country by the late Sir CHARLES WHEATSTONE. These experiments were repeated, and perhaps improved upon, in America, by Professor HENRY, of the Smithsonian Institute, and others. I may direct your attention for a moment to one of these earlier telephonic experiments in America. Two pianos were placed, one on each side of the road. A long deal rod was taken across the street from the window of one house to that of the other, and the two ends of the rod were connected to the sounding-boards of the pianos. Under these circumstances, when a person played the piano in one house, the piano in the other house seemingly played by itself. The vibration of the sounding-board was communicated mechanically through the long wooden rod, and, at the other end of this wooden circuit, the sounding board of the

other piano was set into vibration, and the strings of the piano, which were in unison with those of the first one, were thrown sympathetically into action, and produced music.

'Another telephonic experiment may be seen going on in the streets of London on almost any day. You may see persons in the street exhibiting a small membrane with a thread or a string attached to the end of it, and at a distance of 100 yards or so there is another membrane. The two membranes are united by this thread or string, and if you talk to one of these membranes it is thrown into vibration, and that vibration is mechanically communicated through the string to the other, and the sound is produced in the other membrane. If you observe for a moment the *modus operandi* of the thread telephone, you will see that there are two membranes which control one another's action through the vibration of a string. One of these membranes is forced to vibrate; it pulls the other by the string and releases it, and the two vibrate together. In this case, then, the sound is mechanically conducted along the string; but in electric telephony the sound is not communicated along the wire at all. It exists in the wire as a current of electricity, which produces, *de novo*, the vibration of a sound at the receiving end of a circuit.

'In examining the means by which sound can be electrically produced, I would direct your attention to several distinct species of what may be called telephonic currents of electricity. I distinguish three varieties of telephonic currents, which I will designate intermittent, pulsatory, and undulatory. The characteristic of the pulsatory current is a pulsatory change in the intensity of the continuous current; but the undulatory current, to which attention will be chiefly directed to-night, is a continuous current of electricity, the intensity of which varies gradually, and in a manner proportional to the varying velocity of a particle of air.

'The three radical varieties of telephonic currents may be subdivided into direct and reversed currents, or those in which the impulses are all of one kind, either positive or negative, and those in which the impulses are reversed or are alternately positive and negative. You may still further discriminate varieties of direct currents accordingly as the impulses are all positive or negative. You may have a positive intermittent, or a negative or reversed intermittent current, so that you have nine varieties of telephonic currents.

'So far as I am able to find, all previous experimenters in this branch of science have used intermittent or pulsatory currents in their attempts to produce sound, and I believe that I am the first to conceive of the employment of undulatory currents, whereby not only a noise or musical sound may be produced electrically, but sound of any kind—the *timbre* of the sound as well as the pitch and force of it being preserved.

'The question will naturally arise in your minds, How can these currents of electricity be produced? It will be my object chiefly to speak of the undulatory current and the means of producing it; but I may here state that I have not yet been able to produce a true undulatory current, and the methods which I shall show you are only approximately undulatory. I shall first consider one of the means by which intermittent currents of electricity can be produced. This is illustrated by an apparatus devised by Helmholtz, consisting of a tuning-fork placed between the poles of an electro-magnet; a platinum wire attached to one of the prongs of the tuning-fork dips into a cup of mercury, thus completing a voltaic circuit. So long as the platinum wire touches the mercury, a current of electricity traverses the circuit, passes through the fork, and then through the electro-magnet, and so to the other pole of the battery. Under these circumstances, so long as the circuit is closed, the soft iron core of the electro-magnet attracts the prongs of the tuning-fork, and the result is that the prongs are separated: the result of that is that the platinum wire is lifted out of the mercury; the moment it leaves the mercury the circuit is broken, the current of electricity ceases, the magnetism of the magnet ceases, the attraction of the iron core ceases, and the fork springs back by its own elasticity. Hence, the moment the platinum wire touches the mercury again, the prongs are again attracted apart, and are again released, so that the result is that the fork is thrown into continuous vibration, and at every vibration it makes and breaks the voltaic circuit, thus causing an intermittent current of electricity.

'The means by which a musical tone can be produced by means of this intermittent current of electricity is by a fork, also arranged by Helmholtz, by which one tuning-fork is made to communicate its vibrations to another fork of the same pitch, by means of an electrical current conveyed through a wire. By the use of a resonator placed in front of the second fork, you can reinforce the sound and make it louder or softer, by opening or closing the orifice of the resonator. There was another arrangement by Helmholtz, by means of which a number of tuning-forks are set in simultaneous vibration by the action of one fork dipping into mercury, so that you have a large number of musical tones produced simultaneously from these forks. Helmholtz

made a very remarkable experiment with these forks, varying their loudness by resonators, so as to combine the musical tones in different proportions, and the result was that he was enabled to copy the *timbre* of sound. He was able to produce by this external reinforcement of the forks, the effects of certain vowel sounds, for instance, *oo* or *ah*, different forks being reinforced in different degrees.'

The Professor next produced a diagram of an apparatus for the production of an approximately undulatory current of electricity. 'I have here,' he said, 'a harp of steel rods attached to the poles of a powerful permanent magnet, and the same arrangement is repeated at the other end of the circuit. Between the rods of this harp we have at each end an electro-magnet. We know that when we move a magnet in the neighbourhood of an electro-magnet we induce in the coils of the electro-magnet a current of electricity, the intensity of which is proportional to the velocity of the motion of the magnet; and not only so, but the kind of current, or its polarity, depends on the direction of the motion of the magnet. Hence, we have our undulatory current of electricity. This undulatory current may be utilised to produce a sound at the distant end of the current in the following way:—Let us suppose, for instance, that we have these two harps, that we pluck with the finger one of these rods; it vibrates, and produces a certain musical tone. In vibrating, we have an undulatory current of electricity produced, which traverses the circuit and passes round the coil of the distant electro-magnet. What is the result there? The result is, that this electro-magnet alternately attracts and repels the rods about it—the positive current attracting, and the negative current repelling, them; so that when an undulatory current traverses it we have a succession of positive and negative impulses, and the soft iron core alternately attracts and repels the rods above it, and the rod which is in unison with the one agitated at the other end will be thrown into vibration. So that, if you were to play a tune upon this harp, the corresponding rods at the other end would be thrown into vibration, and the tune would be reproduced. But you will observe that the vibration of this harp is not communicated through the wire mechanically—as in the case of the piano experiment that I have referred to—but the vibration of the rod creates or induces a current of electricity, which current traverses the wire (of course, with the speed of electricity), and will go to any distance, so that instead of having one of these pianos on each side of the road, you may have them hundreds of miles apart, and a telegraph wire between them, and play one piano, and the other will appear to play by itself.

'By Helmholtz's apparatus for the artificial production of vowel sounds, we see that certain *timbres* of sound are produced by causing the tuning-forks to sound simultaneously, with different relations of force. By the arrangement just described we can cause certain of the rods of the harp to vibrate with certain relations of force. For instance, if one of these rods is plucked very forcibly, the current of electricity produced will be very intense, because the intensity of the current depends on the velocity of the moving body. Hence, when you vary the amplitude of the vibration, you vary the intensity of the current. Accordingly, if you pluck one of the rods very forcibly, you will have an intense current produced, and the corresponding rods will be thrown into vibration forcibly; but if you pluck the rod gently a feeble current will be produced, and the rod at the other end is thrown into vibration feebly. If you sound a number of these rods simultaneously, with different relations of force, you will find the rods of the corresponding harp thrown into vibration, with corresponding relations of force. So that if you can produce a vowel sound by vibrating simultaneously a number of these rods, you can transmit a current of electricity which will produce the same sound from the harp at the other end of the wire. If you sing into a piano, keeping the pedal down so as to leave the strings free to vibrate, you will find that not only is the pitch of your voice echoed back to you from the piano, but also an approximation to the quality of the vowel. If you sing *ah* or *oo*, you will find an approximation to these sounds produced from the piano. And the theory shows that if the piano had a very much larger number of strings to the octave, we should have not an approximation but a *fac-simile* of the vowel sound. When you sing the sound into the piano, certain of the strings are set in vibration sympathetically by the voice, with different degrees of amplitude, and the result is that you have these strings going on vibrating after the voice has ceased, with the result that the force and the vowel sound is echoed back.

'The first form of articulating telephone was the following: If you had a large number of steel rods to the octave, and were to speak in the neighbourhood of such a harp, the rods would be thrown into vibration with different degrees of amplitude, producing currents of electricity, and would throw into vibration the rods at the other end with the same relative amplitude, and the *timbre* of the voice would be reproduced.

'However, there are still simpler methods of producing undulatory currents of

electricity, and the best way of showing the method of producing the required current will be to trace the various steps by which the present telephone has grown from the apparatus just shown.

'The effect produced upon the line of wire by the vibration of two of the rods of the harp has been described; and the effect of vibrating a number of permanent magnets simultaneously over an electro-magnet must be considered.

[Professor BELL, in his lecture, described in detail, and showed by a diagram, the result of the combined vibrations of two notes, forming a major chord, the ratios of the vibration being as 5 to 4, and the resultant curve being the algebraic sum of the two.]

'The effect is, when you vibrate more than one of these rods simultaneously, to change the shape of the electrical undulation, and a similar effect is produced when a battery is included in the circuit. In this case the battery current is thrown into waves by the action of the permanent magnets. Hence, you will see that the resultant effect on the current of a number of musical tones is to produce a vibration which corresponds in every degree to the moving velocity of the air. Suppose, for instance, you vibrate two rods in the harp, you have two musical notes produced; but of course if you pay attention to a particle of air, it is impossible that any particle of air can vibrate in two directions at the same time; it follows the resultant form of vibration. One curve would show the vibration of a particle of air for one musical tone, the next one for another, and the third the resulting motion of a particle of air when both musical tones are sounded simultaneously. You have, by this apparatus, the resultant effect produced by a current of electricity, but the same resultant effect could be produced in the air. The resultant vibration of the air from different sounds, that is, the variation of the velocity of a moving particle of air, represents graphically the movements of air for certain vowel sounds. There was a cone into which you spoke, which condensed the air from your voice; at the small end of the cone you had a stretched membrane, which vibrated when a sound was produced, and, in the course of its vibration, it controlled the movement of a long style of wood, about 1 ft. in length, and those curves were drawn by the style upon a surface of smoked glass, which was dragged rapidly along. I uttered the vowels that are here shown, viz., *e, ay, ah, eh, aah*; these vowels were sung at the same pitch and with the same force, but you will observe that each is characterised by a shape of vibration of its own. In fact, when you come to examine the motion of a particle of air, there can be no doubt that every sound is characterised by a particular motion. It struck me that if instead of using that complicated harp, and vibrating a number of rods tuned to different pitches, and thus creating on the line of wire a resultant effect, we were at once to vibrate a piece of iron—to give to that piece of iron not the vibration of a musical tone, but to give it the resultant vibration of a vowel sound—we could have an undulatory current produced, directly, not indirectly, which would correspond to the motion of the air in the production of a sound. The difficulty was, however, how to vibrate a piece of iron in the way required. The following apparatus gave me the clue to the solution of the problem in the attempt to improve the phonautograph:—I attempted to construct one modelled as nearly as possible on the mechanism of the human ear, but upon going to a friend in Boston, Dr. CLARENCE J. BLAKE, an aurist, he suggested the novel idea of using the human ear itself as a phonautograph, and this apparatus we constructed together. It is a human ear. The interior mechanism is exposed, and to a part of it is attached a long style of hay. Upon moistening the membrane and the little bones with a mixture of glycerine and water, the mobility of the parts was restored, and on speaking into the external artificial ear, a vibration was observed, and after many experiments we were able to obtain tracings of the vibration on a sheet of smoked glass drawn rapidly along. Many of these were very beautiful. I would direct your attention to the apparatus itself, as it gave me the clue to the present form of telephone. What I wanted was an apparatus that should be able to move a piece of iron, in the way that a particle of air is moved, by the voice. It struck me in the course of these experiments that there was great disproportion between the tissue of the membrane and the bones that were moved by the membrane, and that if such a thin and delicate membrane could vibrate a mass of bone, so disproportionate in size and weight, perhaps a membrane might be able to vibrate a piece of iron in the way required. I therefore constructed a second form of articulating telephone, founded on the first apparatus, by which I was, at the time of these experiments, producing undulatory electricity for the purpose of producing musical tones. It was similar to the former arrangement, except that instead of being attached to a permanent magnet it was attached to one pole of an electro-magnet, and magnetised by means of a battery current. A current being passed through the coils of the magnet, this piece of iron became magnetic, and a rod attached to one pole would of course become magnetic also, as if attached to a permanent

magnet, so that, on vibrating the rod in any way whatever, the battery current was put in operation, and the corresponding rod at the other end thrown into vibration. I, therefore, took this apparatus, and instead of clamping the rod firmly, it was attached loosely to one extremity of the magnet, and the other end was attached to a stretched membrane of goldbeater's skin; and the same at the other end. The idea was that on speaking to this membrane, it would be thrown into vibration, and cause the vibration of the piece of iron, that, in fact, the iron would follow the motion of the membrane, that is, of the particles of air; it would, therefore, induce an undulatory current of electricity, the intensity of which would vary with the motion, and at the other end the intensity of the magnetic attraction would vary in a similar way; so that the piece of iron at the other end, being attracted and repelled in a varying manner, would be thrown into vibration, copying the motion of the first, and it in turn would cause the motion of a second stretched membrane, which would move the air in the neighbourhood, and we should thus have a sound produced. The idea was, that not only would the two pieces of iron vibrate together, but the form of the vibration would be the same, so that on speaking in the neighbourhood of one membrane we should have a *fac-simile* of the sound produced at the other end. The apparatus was constructed, but the results were rather unsatisfactory. My friend, Mr. THOMAS WATSON, who assisted me, asserted that he could hear a very faint sound proceed from the second membrane when I spoke in the neighbourhood of the first. Encouraged by this fact, I varied the apparatus in a number of ways, and eventually produced three distinct forms of apparatus, which were exhibited at the Centennial Exhibition. I came to the conclusion that this piece of iron was probably rather too heavy to be set in vibration by the membrane, and I therefore made it as light as possible; in fact, I took a piece of steel spring, only about the size of the pole of the electro-magnet itself, and glued it to the centre of the membrane. Upon constructing two of these instruments, there was no mistake at all that articulate speech was produced; but it was of a very imperfect nature. When a person sang or spoke into one of these instruments, you could distinctly hear the tones of the speaker's voice at the other end, and could recognise that there was articulation there, and when you knew the sentence that was uttered, you could recognise the articulation, and it seemed strange that you could not understand what it was at first. The vowel sounds seemed to be copied very fairly, but the consonant sounds were entirely alike.

'Another form of apparatus was constructed at this time for producing an undulatory current. It consisted of one portion of the apparatus turned horizontally; attached to the membrane of gold-beater's skin is a little bit of cork carrying a platinum wire, which dips into a cup containing water. We know that water offers an enormous resistance to the passage of an electrical current. If you place two wires in water, separated by a slight distance, the resistance offered by the water is very great; but if you bring the wires nearer together, the resistance becomes less and less, so that the current of electricity becomes stronger and stronger, and when the two wires can be put in actual contact the resistance of the water may be ignored altogether. Hence you can see that by vibrating two wires to and fro in a liquid of high resistance included in the circuit, the battery current can be thrown into waves, and the resulting current may be considered as approximately undulatory; and with this form of apparatus I was able to produce articulate sounds. But it was no improvement on the first. I produced the effect of articulate speech by vibrating the conducting wire in this way in pure water, in water acidulated with dilute sulphuric and other acids, in salt and water, and in a number of other liquids. I also produced the same effect by vibrating a solid of high resistance in a liquid of low resistance. Instead of a platinum wire dipping into water, I had plumbago dipping into mercury. The plumbago offered a good deal of resistance to the passage of the current, but as it dipped into the mercury it offered less and less, and by having a very small piece of plumbago vibrating in the mercury, the current was varied in a manner approximately undulatory, and articulate effects were produced when this apparatus was used as a receiving instrument.

'I found, however, that the best means I could devise for producing an undulatory current was the apparatus I will now show you, but it did not serve well as a receiving instrument, and I was therefore led, after many experiments, to construct another form of receiving instrument, keeping this for transmission.

'The form of receiving instrument to which I was next led consisted of a hollow box of iron, with the electro-magnet inside, and a thin diaphragm of iron laid on the top as a lid. Upon resting the ear closely against this diaphragm, articulate sounds were very clearly perceived, when the first instrument, as shown at Philadelphia, was used as a transmitting instrument. I was so convinced, from these experiments, that the inductive method of producing an undulatory current was the best method, that I determined to vary the construction of the first form of apparatus, and I gradually

varied the size and power of my magnet, and the size and thickness of the iron spring attached to the membrane, and the size of the coil. I found, as I diminished the size of the coil, the resulting sound at the other end became very much louder; in fact, I found there was no advantage in using a coil that extended beyond the centre of the magnet. Indeed, there is very little difference, in effect, between a coil of that size and a mere flat spiral placed once round the magnet. The important point is to cover the pole of the magnet. Every succeeding turn adds resistance, without increasing materially the loudness of sound. I varied the power and size of the magnet by varying the power and size of the voltaic battery employed to magnetise it, and found that very little effect was produced by diminishing the power of the battery. In fact, the effect of articulate speech was produced from the receiving instrument when the battery was entirely removed from the circuit. In that case the only source of power would be the residual magnetism of the iron bar, and that showed that the only use of the battery could be to magnetise the iron bar; so, in subsequent forms, I dispensed entirely with the voltaic battery, and used a straight bar of iron-magnetised steel. Increasing the size of the iron plate attached to the membrane, a very large increase in the loudness of the sound resulted, until finally I had a plate of iron almost as large as the membrane itself. By this, dispensing with the membrane altogether, perfect articulation was, for the first time, obtained, and in this form, which differs very immaterially from the present form, you have a plate of iron vibrated by the voice, in front of a permanent magnet with a coil of wire around it.

'On varying the size and thickness of the permanent magnet it is found that wonderfully little difference is produced by magnets of very different force, and on varying the size, diameter, and thickness of the iron plate wonderfully little difference is produced. The chief difference is a peculiar effect on the quality of the voice. I have produced distinct articulations from iron plates all the way from 1 inch in diameter up to 2 feet, and from $\frac{1}{64}$ inch to $\frac{3}{4}$ inch in thickness. In fact, if you take an ordinary Morse sounder, and use that as a receiving instrument, using a battery current to magnetise it, if you place the armature of the Morse sounder close against your ear, articulate sounds are produced from it. This shows very distinctly that the effect is probably molecular rather than anything else, and the vibration of the plate as a whole mars the effect. One of my best forms of instrument was constructed on this model, but I had the cavity completely filled with a pad, to prevent the vibration of the plate as a whole, and it articulated beautifully. When the pad was taken out, a peculiar effect accompanied the articulation—a drum-like effect, due probably to the vibration of the plate as a whole. In fact, I can describe very distinctly the effect produced by varying the size of the plate. Suppose we keep the plate of uniform thickness, and vary the diameter, commencing with a small plate, we have articulation perfectly distinct, but it sounds as if you were speaking with a cold in your head; a purely nasal quality accompanies the sound. Now, keep the thickness uniform, but enlarge the diameter, and as you do so the nasal effect wears away, until, with a certain diameter, you obtain a very good quality of voice. Keep on enlarging it, and a coarse, hollow, drum-like effect is produced, and when you have it very large it sounds as if you had your head inside a barrel—a kind of reverberating sound. So keeping the diameter of the plate uniform and varying the thickness, commencing with a very thin plate, you will have the same drum-like effect. Now, as you gradually thicken the plate, you have the effect disappearing. Then you get articulation, and as you go on increasing the thickness you have that peculiar nasal quality produced, so that it is probable that the fundamental pitch of the plate itself has a great deal to do with the agreeableness or disagreeableness of the electrical articulation, but the size or thickness does not seem to impair the distinctness of the articulation itself. There is a peculiar form of mouthpiece for concentrating the air on the plate. I made one experiment of rather a striking nature, viz., I omitted entirely the cavity in the mouthpiece. The iron plate was glued solidly at every point against a block of wood, and I talked against the surface of the block, so that there was an inch of wood between my mouth and the iron plate. Yet I was able to carry on a conversation with a man three miles away.

'The apparatus described consisted of a strong ordinary magnet, to the two extremities or poles of which are attached properly-insulated telegraph wires. Just in front of the extremities of the magnet there is a thin plate of iron, and in front of this again there is the mouth-piece of a speaking-tube. By this last the sounds which it is desired to transmit are collected and concentrated, and falling on the metal plate cause it to vibrate. These vibrations, in their turn, excite in the two wires electric currents, which correspond exactly with the vibrations—that is, with the original sounds. If, now, the two wires are connected with an ordinary line of telegraph, specially insulated for the purpose, the sounds can be transmitted to any distance, and, on arriving at

their destination, are reproduced in a precisely similar apparatus. Already there are varieties of the telephone, but this is its essential nature.

'The effect of reversing an undulatory current is to strengthen and weaken the magnet, and the result is that the plate is attracted in a varying manner, and the plate at the receiving end vibrates in a similar manner to the one at the transmitting end, and so a similar sound is produced. You therefore have the voice of the speaker converted into electricity here, and at the other end of the circuit you have the current of electricity re-converted into sound. No voltaic battery is used in this form, nothing but the magnet itself. I may here state one defect of this current. I have stated that I have not yet discovered the means of producing a strictly undulatory current. It frequently happens that for practical purposes the current is sufficiently undulatory to produce at the other end the effect of articulate speech, but the current produced in the coil is not strictly proportional to the velocity of the motion of the plate, as was pointed out to me by my friend Professor Cross, of the Institute of Technology at Boston, for there is another effect produced depending on the proximity of the iron plate to the pole of the magnet. If it be moved with a certain velocity, and the plate is very near the pole of the magnet, the effect produced would be very much greater than if it were farther away; so that you have the approximation or the separation of the two affecting the result. In fact, when the plate vibrates towards the pole the current produced is too strong, and when it goes from the pole of the magnet it is too weak, so that the effect is not strictly an undulatory current. If the amplitude of the vibration of the plate is very great the defect is magnified, but if it is lessened the effect more nearly approximates to the undulatory character. Hence the curious effect that soft speaking is much more distinct than loud speaking. If you shout or roar into the telephone you have the sound produced at the other end very loudly; but a discriminating ear will recognise that the articulation is not so distinct as when you speak more softly into the instrument. However, theory shows one way in which the defect can be remedied. Suppose we have alternate impulses going along the wire, and that when the plate comes towards the magnet we have a positive current produced, and when it goes away a negative current. The coil may be so arranged that when the positive current traverses it the magnet will be strengthened, and it will then attract the plate with greater force; and thus, when the first plate approaches the magnet the other will do the same, and thus the defect will be magnified. But we may also arrange the coil so that when the first plate approaches the magnet the other will recede from it, and thus the effect I have spoken of will be neutralised.

'This leads me to a very curious point in the use of the telephone, viz., that you can control the phase of a vibration by specially arranging the coil. You can take two telephones and arrange them so that while some person makes a musical tone into the receiving instrument, the phases of vibration of the plates shall be identical or opposed. Sir William Thomson made an experiment of this kind with me in Glasgow, and we found that the telephone is a beautiful instrument for illustrating the interference of sound. If you arrange the instruments so that you have the phase of vibration the same, and then place your ear to the instrument, you can perceive the sound approximately doubled in intensity; but arrange them so that the phases are opposite and there is a "dead spot,"—silence is produced at one point. I never heard interference of sound so beautifully illustrated as in that experiment, and there is no doubt that many uses can be made of the instrument in acoustics, from the fact of our being able to control precisely the relative phases of two vibrating bodies. The experiments made with this telephone by Sir W. Thomson have demonstrated the fact of an interference in the perception of sound. For instance, take two instruments, one vibrating in a certain phase, and the other in a phase nearly, but not quite, the same. Place one to one ear, you perceive the sound on that ear alone. Place the other to the other ear and you perceive it on that ear alone. Place them to both ears at once, and you can arrange the phases of vibration so as to make both tympanic membranes act at the same time, or vibrate in a different manner; and there is a curious difference in the perception of the sound. It cannot be described, but it is something of this kind. You place the instrument to each ear in that way; where the phases are identical you have a single sound, and you may localise the sound say on the surface of the two ears, but when the phases of the vibrating plates are reversed, the locality of the perception seems to change, and it seems as if you heard the sound at the back of the head instead of at the surface of the ear. Moreover, if you take two distinct circuits, and have one telephone on one circuit and one on the other, and have a musical tone produced from one telephone, which is almost, but not quite, in unison with that produced from the other, you have beats.

'We know that if two organ-pipes, for instance, were vibrating in this room, the pitches of which were adjusted in that way, we should be cognisant of beats illustrating the interference of sounds of that sort. Sir William Thomson writes me that

he has shown that the same effect is produced in the sensation of sound, for, placing one plate to one ear and the other plate to the other ear, so that each ear perceived only one sound, the same effect of beats was produced, showing very conclusively the interference in the sensation of sound itself.

'For the actual purpose of conversing at a distance it is preferable to employ two telephones, one in front of the mouth and the other at the ear, for it has been found that when one telephone alone is employed it constantly happens that persons separated by miles of distance speak at the same time or listen at the same time; and by placing one telephone to the ear and the other to the mouth, conversation at once becomes practicable.

'Of course the question will naturally arise how far it can be possible to use the instruments. That as yet we do not know. The limit has not been found. In laboratory experiments no difficulty has been found in using an apparatus of this construction through a circuit equivalent to 6,000 miles. In this instrument we have a powerful compound permanent magnet. The longest actual wire I have been able to experiment upon has been 258 miles in length, and no difficulty was experienced so long as the other parallel wires were not in operation. The instrument is wonderfully sensitive to inductive influences; and when you use a wire upon the poles with other wires, you have the benefit of the other messages that are passing along the other wires on the telephone. However, means have been discovered very recently by which the inductive influence of other wires can be overcome and neutralised, so that I hope we may have the instrument in use upon circuits of all lengths. I do not know that there are any other points that I should like to mention, excepting a new application that is shown here to a diving apparatus. Inside the diver's helmet you place a telephone of convenient structure, and in the place of using a separate telegraph wire we use the wire that is coiled up inside the breathing pipe. In every breathing pipe of course there must be a coil of wire, in order to withstand the pressure of the water, and that wire we find can be used for the purposes of the telephone; so that the wire inside this pipe is connected with the telephone inside the diver's helmet, and the earth connection is simply made by attaching the other wire to the helmet itself, which is in contact, outside, with the salt water. I had the pleasure of trying to converse with a diver yesterday, with perfect success, at Messrs. Siebe and Gorman's, in a tank. He heard every word I said, and I was able to understand every word he said; and when I told him to come up, by word of mouth, he obeyed me.'

2550

2551

The actual construction of the telephone will be perfectly understood by reference to the accompanying woodcuts. *Fig.* 2550 represents the complete instrument in the

form at present employed by Mr. GRAHAM BELL. This is shown in section in *fig.* 2551. The diagram (*fig.* 2552) illustrates more fully the arrangement of the two

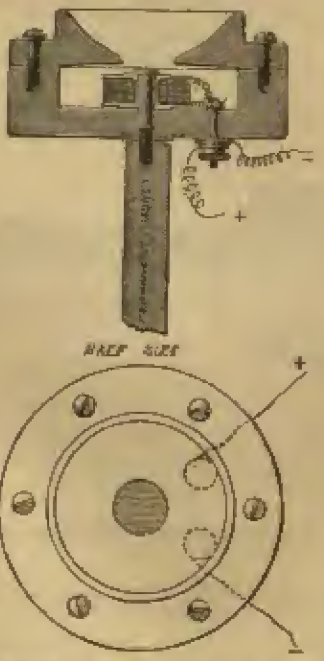
2552

instruments at each end of a line. The two instruments are here shown, with E E, their earth connections, and the wire communication, which, of course, may be separated to any distance. *a a* are discs of thin iron plate, placed immediately within the orifice of the mouth-piece of the instrument, and directly in front of the permanent magnets, N S, and at a very short distance from it, about $\frac{1}{100}$th of an inch; *b b'* are coils of copper wire covered with silk, which are placed quite at the extreme end of the magnet, being wound on the reels, *c c'*. This wire is connected at each, and with the line at one end, and earth, E E, at the other, so as to complete the circuit.

Fig. 2553 represents a modified form of the instrument, drawn to half size, which appears to possess some advantages.

Mr. T. A. EDISON, of New York, has endeavoured to remedy some of the defects in

2553



BELL's instrument by introducing a transmitter which is operated on by battery currents, whose strength is made to vary directly with the quality and intensity of the human voice. In carrying out his investigations he discovered that the resistance of plumbago varies inversely with the pressure brought to bear upon it. He there-

fore substitutes for Reis's transmitter a small cylinder of plumbago for the platinum point, *d* (*fig.* 2554), and he finds that this cylinder varies sufficiently with the pressure of the vibration of the diaphragm to cause the current transmitted to vary in form and strength to reproduce all the varieties of the human voice.

His receiver is peculiar. He attaches to a resonator, *a* (*fig.* 2554), spring, *b*, whose platinum face, *c*, rests on chemically prepared paper; whenever the drum, *c*, is rotated and currents sent through the paper, the friction between *c* and *a* is so modified that vibrations are produced in the resonator, *a*, and these vibrations are an exact reproduction of those given out by the transmitter at the other station.

2554

Mr. Edison has yet more recently produced an instrument, which he names the 'Phonograph.' In the course of his researches, and especially while engaged in the experiments in connection with his speaking telephone, he conceived the idea of recording the human voice upon a strip of paper, from which at any subsequent time the sentences uttered might be reproduced automatically, with all the vocal characteristics of the original speaker. At present, his invention has only reached that preliminary stage in which it gives promise of an extraordinary future; but it has been sufficiently developed to leave no doubt in Mr. Edison's mind that in the course of twelve months he will be able to accomplish all he has now publicly announced. For obvious reasons the details cannot be made known, nor are they, indeed, definitively settled; but the following explanation will render the principle of the invention clear. A mouthpiece and short tube is closed at one end by a flexible diaphragm of thin iron or other material, carrying a chisel-shaped point in its centre. This vibrating 'drum' is supported in such a position that the chisel point is made to indent a strip of paper which passes over a roller beneath. The paper is coiled on a reel at the side, and has a V-shaped ridge running along the centre—such a ridge as would be made by a Morse register with the lever constantly depressed. The roller over which the paper passes is driven by clockwork, and the slip is consequently drawn at a uniform but rapid rate beneath the point. On speaking into the mouthpiece the flexible diaphragm is caused to vibrate, and its vibrations, as we know from the telephone, are sufficiently varied to make characteristic indentations in the ridge of the paper slip. The ridge being unsupported, except by the substance of the paper, is susceptible to the slightest movements of the chisel, and as the latter is operated by the aërial vibrations directed against the diaphragm, the sound-waves of small amplitude produce slight indentations, while the more powerful tones of the voice are recorded by deeper impressions. It will be understood that by this means a strip of paper is prepared, having on the fine edge of its ridge a series of depressions more or less close together, and varying in depth. If these correctly represent the vibrations produced by the speaker's voice, and it is possible by their means to reproduce similar vibrations on the diaphragm of another instrument, the exact words of the original speaker will be re-uttered by the diaphragm of the reproductor. That instrument resembles the productor, save that it has a more delicate diaphragm, which is put into vibration by the least motion of a point travelling over the indented slip of paper. A V-shaped point is used as the traveller, and it is connected by means of a hair-spring with a thread attached to the diaphragm.

Application of the Telephone to Mining.—The first experiment with the telephone in mines was made by Mr. Arthur Le Neve Foster in West Wheal Eliza, a tin mine near St. Austell, in Cornwall. Dr. Clement Le Neve Foster favours us with the following account of this experiment:—

'My brother Arthur and I made some experiments with the telephone on September 4 last at West Wheal Eliza. My brother went down in the 'gig,' lowered by the capstan rope, and payed out the wires (two insulated copper wires) as he went. For 10 or 15 minutes we were talking to one another. West Eliza is 42 fathoms deep from surface. My brother went a little way into the level, and I stopped at the brace. Talking, whispering, coughing, and singing were plainly heard both above and below, and we could readily distinguish the voices. It was found that the clank of the drawing lift interfered with the hearing a little down below, but when the engine was stopped every sound was very plain. I chose West Eliza, as it just suited the length of wire which my brother had, viz. 45 fathoms. We tried making the current go through people by interposing several in the circuit, and this of course worked all right. I should say that the telephones used were made by my brother himself, from descriptions he had read of Professor Bell's instruments.'

An experiment, suggested by Mr. HENRY HALL, of Rainhill, Prescot, the Government Inspector of Collieries, was made at the Prescot Colliery of the WIGAN AND WHISTON COAL COMPANY, Mr. A. LE NEVE FOSTER being the active experimentalist. The following account of the experiments is derived mainly from the *Telegraphic Journal*:—

'For the experiments about 600 yards of ordinary insulated wire were used, the end in one instance being at the bottom of the pit, while the other end, brought into connection with the BELL telephone, was brought into the office. Mr. HALL and his party went to the bottom of the pit, while others remained in the office.

'The apparatus was first used for the purpose of communicating with those in the mine, and the success was complete. Even the cheering of the colliers at a distance from the instrument was distinctly heard in the office. The instrument was then tested in relation to the principal practical purpose to which it is hoped it may be applied, the indicating on the surface the action of the airometer below. The airometer, the invention of Mr. HENRY HALL, the inspector, by means of a delicately-constructed windmill, shows the rate of the current of air in the passages of the colliery.

'The registration on the surface of the action of the airometer underground is effected by making that instrument, after a certain number of revolutions, act on a spring, which vibrates against the telephone, and, setting it in vibration, the overseer on the surface is by the sound conveyed informed of the rate at which the current of air is running in the mine. This was most effectively carried out.'

TELLURIDE OF CADMIUM. (Cd Te.) Prepared by heating cadmium with tellurium to about 500°. The product is amorphous, and has a metallic lustre.

TELLURIDE ZINC. See ZINC, TELLURIDE.

'*Telluric silver* has been lately found in Chili, in grains of 3 and 5 decigrams. It was contained in masses of chloride, carbonate, and sulphate of lead.

'*Tellurate of lead*, bright yellow amorphous particles, soluble in hydrochloric acid. These minerals were found in the abandoned mines of Condoriaco (Coquimbo). —F. DOMEYKO, *Comptes Rendus*, lxxxi.

TELLURIUM. 'The ores produced by the mines of Nagyág and Offenbánya are remarkable as containing a comparatively large proportion of the rare element tellurium, which, although it has hitherto been of no commercial importance, has latterly been in some demand on account of a new application for the construction of thermo-electric batteries. The following experiments have been undertaken to discover a cheaper method of production than those heretofore in use.

'The ore, as delivered for smelting, was found to be of the following average composition: quartz, 30 to 40 per cent.; carbonate of lime, 10 to 20 per cent.; carbonate and sulphide of manganese, 15 to 20 per cent.; alumina, 5 to 8 per cent.; galena, 5 to 8 per cent.; copper pyrites, 1 to 2½ per cent.; blende, 1 to 4 per cent.; and small quantities of cobalt, nickel, antimony, arsenic, tellurium, gold, and silver.

'When such a mixture of minerals is roasted, a portion of the tellurium and gold are volatilised, and may be recovered in properly-constructed condensing chambers. The manganese compounds are converted into manganic oxide, while the greater part of the gold is reduced, so that about 50 per cent. of the total amount may be saved by amalgamation. By subsequent treatment of the roasted ore with weak hydrochloric acid, which can be done in wooden vats lined with lead, chlorine is generated in considerable quantity, through the action of the manganic oxide, and the whole of the valuable metals present, with the exception of silver, which remains in the insoluble portion, are converted into soluble chlorides. Any excess of chlorine produced in this operation is economised by condensation in water, which gives a liquor that can be used for redissolving the crude tellurium. The solution of chlorides obtained by this treatment is next cleared from lime and lead, which are precipitated as sulphates, by the addition of sulphuric acid. The separation of these sulphates is effected by subsidence and decantation, as filtration is found to present considerable difficulties.

'Gold is next precipitated from the clear solution by the addition of a solution of sulphate of iron; and after filtration, tellurium, by the action of metallic zinc, which produces a black, muddy precipitate. This may, after washing with hydrochloric acid and rapid drying, be converted into crude tellurium by fusion, without any flux, in a porcelain crucible; but the product so obtained invariably contains lead, copper, nickel, and antimony, and it is therefore preferable to redissolve the first telluriferous precipitate in chlorine water, and subject the solution for a considerable time to the action of sulphuric acid, whereby tellurium in a high state of purity can be obtained.

'The original residue of the chlorination treatment contains, in addition to silver as chloride, some gold in a soluble state. By the addition of sulphate of iron to

these residues when in a moist condition, the gold may be reduced, and the substance is then fit for treatment by amalgamation; but fusion with lead, when it can be done, is generally preferable.

'The following results were obtained in an experiment conducted according to the above principle: 14·5 lb. of tellurium ore, containing 14 dwts. of gold and 13·0 dwts. of silver, were roasted for an hour and a half in a muffle furnace. The loss of weight was equal to 7·2 per cent., and 0·35 per cent. of gold and 3·8 per cent. of silver were computed as lost by volatilisation. The roasted ore weighed 14·3 lb., of which quantity 13·2 lb. were taken for subsequent treatment by chlorine. This was effected by mixing it with 10·4 pints of water, 6·6 pints of crude hydrochloric acid (25° B.), and 10·6 ozs. of concentrated sulphuric acid. The addition of the acid was attended with effervescence, owing to the rapid evolution of carbonic acid and chlorine.

'After twenty-four hours, the solution was diluted by the addition of 6·8 pints of water; the whole contents of the dissolving vat were stirred well together and allowed to settle for two hours, when the clear liquor was drawn off. This operation was repeated three times, giving a total quantity of 9 gallons of liquor, which was then treated with a solution of green vitriol (3·5 pints of 25° B.) in order to separate the gold. This was completely effected in twenty-four hours, and the resulting gold, after being washed, dried, and cupelled with lead, weighed 10·5 dwts., or 82·2 per cent. of the total contents of the ore treated—an amount that might have been increased to 90 per cent. if the washing of the residue had been more completely carried out.

'The liquor remaining after the separation of the gold was next treated with 4·4 lb. of commercial zinc. The black mud precipitated, after standing twenty-four hours, when washed, dried, and melted, yielded 12·3 dwts. of crude tellurium, or about 0·42 per cent. of the weight of the ore operated upon. The consumption of zinc was about 6 per cent. of the weight of the ore. The argentiferous residues were found to contain 2·5 dwts. of gold and 10·6 dwts. of silver. The final result, therefore, gave about 2 per cent. of gold in excess of that indicated by assay, while the loss of silver was about 8·0 per cent. These differences, especially that of the gold, the author ascribes partly to the difficulty of sampling, owing to the unequal distribution of very rich minerals in the mass of earthy substances forming the ore, and partly to the irregular loss by volatilisation of the precious metals with the tellurium in the assaying processes, which is always observed with these minerals. The author concludes by pointing out that this method is likely to be of considerable value to the Nagyág and Offenbánya mines in the event of a demand for tellurium arising on a large scale.'—*Experiments on the Production of Tellurium from the Transylvanian Gold Ores*, by A. Hauch, *Oest. Zeitschrift für Berg- und Hüttenwesen*, vol. xxiv. p. 240. (*Abstracts of Papers in Foreign Transactions*, Institute of Civil Engineers.)

TERMINALIA CHEBULA. The tree producing myrabolans, which are much used in dyeing on account of the tannin they contain.

TEXTILE MATERIALS. (See Textile Fabrics, vol. iii. p. 979.) The vast collection of fibres gathered together at the late Centennial Exhibition furnished an opportunity of grouping the varieties of textile materials of all kinds. The Cotton Exhibition at Philadelphia presented naturally a fine display of cotton fibres, the United States being the greatest cotton-producing country in the world. Amongst the most remarkable were the following:—Sea Island long staple cotton, from Florida; other examples from South Carolina and Georgia, both of which states produce the finest and most valuable of cottons. Texas supplied some good cotton, and good samples were shown from the Red River, in Upper Louisiana. (See Cotton.) From countries other than the United States, specimens were furnished by—

Australia, Queensland.—Admitted to be equal to the American cotton.

The Fiji Islands.—Of long, delicate, silky fibre, adapted for spinning.

Brazil.—The cottons from Pernambuco, Parahyba, and Maranhao, were excellent in quality.

The Argentine Republic.—From the provinces of Catamarca and La Rioja.

Jamaica.—Especially samples of wild cotton.

New Caledonia.—Some fine examples of long and delicate cotton were shown.

The Philippine Islands.—These are of short staple and unequal in quality.

Cuba sent the long pods of *Bombax pentandra* crowded with seed and covered with a cotton-like fibre.

Egypt.—From the estates of the Khedive various samples were shown.

Russia contributed cotton, both white and dark buff, produced in small balls from Bucharia and the neighbourhood of Samarcand.

Wool.—Wool was to be found exhibited by a number of countries. For the United States individual exhibitors seem to be almost entirely wanting, although wool production is a matter of no small importance in several regions of the country. While the

collection included wool from a number of the northern and middle States, it was especially rich and interesting in specimens from a belt stretching across the continent further south, and including Texas, part of Mexico, New Mexico, Nevada, Colorado, and California. The New Mexican and Californian specimens were particularly interesting; some of the latter, from imported herds, showed the marvellous fertility and variety of production of the States whose names have long been associated with gold, but which yield many other treasures of perhaps more permanent importance.

There were some good examples of Spanish and Australian wools. From Spain a fair representation of her merino wool of fine quality, some of the best coming from Sevilla; Madrid and Huelva being also creditably represented. There was quite a considerable proportion of black merino. Burgos sent some very long combing wool, and from Murcia came one very curious specimen of fine white merino, quite short, and with a very singular close, crisp curl. Portugal had a large and well-selected series of wool samples, amongst which the black wool of Braganza and Evora was quite noticeable. In the German section there was one small but choice display of Silesian merino wool from Carlsdorff, near Jordansmühl. A number of samples both of wool clipped and in the fleece came from the Argentine Republic—much of the fleece wool 4 inches to 5 inches long, and remarkable for rapidity of growth. Most of this comes from Buenos Ayres, and was more remarkable for weight than fineness. There were one or two exhibitors of alpaca wool from the Argentine Republic, but the representation was quite inadequate. One very remarkable fleece, of a pure Negrette ram, was said to weigh 31 lb. The Australian Colonies made quite handsome contributions in this department, and sustain their claim to rank amongst the most important regions of production. New South Wales had a large and fine lot of wools—nearly all merino. One of the best individual contributions was that of Bramnarah and Jarny—long, fine, crisp merino wool. A. H. Lowe, of Pynever, had Angora wool, product in part of a flock of some 300 animals. Victoria sent two or three important classified assortments of samples from Port Phillip, besides a number of individual contributions. South Australia had also a fine collection—silky Lincoln lambs' wool and long combing merino being most noticeable. Queensland had a few admirable fleeces, one from a colonial-bred ram, of 12 lb., the growth of eleven months. Tasmania sent some thirty samples of good merino and Leicester wool. From the Cape of Good Hope there were not many specimens or of very choice character. Russia made a fine display. Amongst the most interesting features of her collection were the washed wools from Cherson, and a series of merino samples showing length and character of staple, from the Karlopka estate of H.I.H. the Grand Duchess Catherine Michaelovna. In connection with wool may be mentioned two or three interesting English examples, illustrating the production of shoddy, mungo, &c., by tearing to pieces, carding out, and cleaning the material of woollen rags, worn-out garments, blankets, &c., as also the separation of any remains of vegetable fibre. Turkey and the Orange Free State of South Africa sent each a little Angora wool, the former being of beautifully silky character.

Silk.—The Philadelphia Exhibition afforded also an excellent opportunity for the display of silk, especially from new districts. The only one of the United States contributing to any extent was California, where silk culture has been carried on upon a considerable scale and successfully for a number of years. In the Californian section were seen huge piles of cocoons, with beautiful reeled silk, white and yellow; also specimens of the living worms, eggs, &c. Of the old silk-producing countries, there were a few exhibitors of raw silk from the South of France, chiefly from the Department du Gard. Italy also sent a little, and some of great beauty, but not such a representation as might have been expected; and the like may be said of Spain. Portugal had some strong and rather coarse thrown silk, besides cocoons. There was, amongst the Russian collection, a curious lot of silk from Central Asia, looking as if it were probably the product of some other insect than those generally known. In the Egyptian Court there was a showy display of cocoons, but no remarkable product of reeled silk. Japan sent some very beautiful cocoons and reeled and thrown silk. China also sent raw silk. In the South Australian section there was one little case of raw (reeled) silk, presenting an unusually lustrous appearance, which caught the eye at once, though the fibre was somewhat coarse and heavy. Brazil contributed some very good raw silk.

Hemp, Flax, and Miscellaneous Fibres.—Amongst the other varieties of fibres exhibited the following may be particularised:—

Esparto, Junco, and Zea, sent from Spanish colonies, manufactured into hard matting, strong cordage, and fine paper.

Pita fibre was sent from the Canary Islands and from the Cape de Verds, and examples of local manufacture.

Caryota urens.—A strong black fibre from the Philippine Islands, together with the *Cane espina or canna* (*Calamus*, Sp.), made into a close hard cordage.

Nabo (*nauclea scabia*).—A soft bast-like fibre from the island of Loyte.

Nito (*Ugena semi-hastata*).—A coarse fibre much resembling coir.

Abaca or *Manilla Hemp* (*Musa textilis*).—Some fibres were exhibited in huge bundles, hanging straight down about 10 feet long, white, strong, fine, and glossy; also *Manilla Hemp* from the islands of Luzon, Leyte, and Mindoro.

Sansciera dracæna, called also *Bowstring Hemp*.—A bright, strong fibre, looking like Manilla hemp, was sent from the Mauritius, and a similar product from the *Urania Madagascariensis* and *Livistona Mauritiana*, closely resembling a very fine hemp.

Jute from the Philippines, and Indian jute from the Portuguese Colonies.

Tapacloth from Hawaii, made by beating out the bark of a tree.

'*Long Moss*' (*Tillandsia usneoides*).—An epiphyte growing in immense abundance, hanging from the boughs of the cypress and magnolia and other trees on the borders of streams and in swamps. It is used instead of curled hair for stuffing mattresses and cushions.

Alfa, or African esparto.

Palm fibre, especially from the dwarf palm.

Broom fibre (*Juncewm Sparteum*), from the province of Pisa, Italy. This was exhibited, and coarse bagging, fine cloth, and paper made from it.

Ife (*Sansciera Angolensis*).—A white fibre from Angola, and some good cordage made from it. From the same country, *Mundonde*, a fibre from an asclepiad plant.

Comagi fibre from the Mozambique coast; a long, strong fibre, much resembling hemp.

'*Natural Wool*,' from a palm of unnamed species, was furnished by Brazil. Also *Asclepias fibre*, from Minas Geraes; *Urena lobata*, resembling Manilla hemp, from Parana. *Fourcroya gigantea* or *Agave fœtida*, a lustrous wiry fibre, three or four feet long, from Bahia. *Bertholletia excelsa*, a spongy fibre from Para, used for caulking ships and for making a coarse paper. Also from San Paulo a harsh cordage made from *Xylopia frutescens*; and from Rio Janeiro the loose fibre of *Chorisia speciosa*, light and silky, used for stuffing mattresses.

Coir, or cocoa-nut fibre, was contributed from Ceylon, India, and other places.

'*Silk grass*,' a plantain fibre, was also exhibited from Ceylon.

A further description of many of these fibres will be found under their respective names in this and the previous volumes.

THALLIUM. (Vol. iii. p. 958.) Professor E. J. Chapman, of University College, Toronto, communicates to the *Philosophical Magazine* for November 1876 the following reactions of metallic thallium before the blowpipe from direct experiments:—

'In a closed tube thallium melts easily, and a brownish-red vitreous slag, which becomes pale yellow on cooling, forms around the fused globule.

'In the open tube fusion also takes place on the first application of the flame, whilst the glass becomes strongly attacked by the formation of a vitreous slag as in the closed tube. Only a small amount of sublimate is produced. This is of a greyish-white colour, but under the magnifying glass it shows in places a faint iridescence.

'On charcoal, *per se*, thallium melts very easily, and volatilises in dense fumes of a white colour streaked with brown, whilst it imparts at the same time a vivid emerald green coloration to the point and edge of the flame. If the heat be discontinued, the fused globule continues to give off copious fumes, but this action ceases at once if the globule be removed from the charcoal. A deposit, partly white and partly dark brown, of oxide and teroxide, is formed on the support; but, compared with the copious fumes evolved from the metal, this deposit is by no means abundant, as it volatilises at once where it comes into contact with the glowing charcoal. If touched by either flame it is dissipated immediately, imparting a brilliant green colour to the flame-border. The brown deposit is not readily seen on charcoal; but if the metal be fused on a cupel, or on a piece of thin porcelain or other non-reducing body, the evolved fumes are almost wholly of a brownish colour, and the deposit is in great part brownish black. It would appear, therefore, to consist of TlO rather than of a mixture of metal and oxide. On the cupel thallium is readily oxidised and absorbed. It might be employed, consequently, as suggested by Crookes, in place of lead in cupellation, but to effect the absorption of copper or nickel a comparatively large quantity is required. When fused on porcelain the surface of the support is strongly attacked by the formation of a silicate, which is deep red whilst hot and pale yellow on cooling.

'The teroxide, as stated by CROOKES, evolves oxygen when heated, and becomes converted into TlO. The latter compound is at once reduced on charcoal, and the reduced metal is rapidly volatilised with brilliant green coloration of the flame. The chloride produces the same reaction, by which the green flame of thallium may easily be distinguished from the green copper flame, the latter, in the case of cupreous chlorides, becoming changed to azure blue. With borax and phosphor-salt thallium oxides form colourless glasses, which become grey and opaque when exposed for a short time to a reducing flame. With carbonate of soda they dissolve to some extent, but on charcoal a malleable metallic globule is obtained. The presence of soda, unless in great excess, does not destroy the green coloration of the flame.

'Thallium alloys more or less readily with most other metals before the blowpipe. With platinum, gold, bismuth, and antimony respectively, it forms a dark-grey brittle globule. With silver, copper, or lead, the button is malleable. With tin thallium unites readily, but the fused mass immediately begins to oxidise, throwing out excrescences of a dark colour, and continuing in a state of ignition until the oxidation is complete. In this, as in other reactions, therefore, the metal much resembles lead.'

As much attention is now given by our miners to the discovery of minerals likely to be of economic value, it appears that the above information must prove of considerable value.

Mr. J. KRAUSE found some difficulty in working the fine dust of Meggen pyrites for thallium by condensed sulphuric acid. With large quantities of dust, obtained from the works of ENGELCKE and KRAUSE at Trotha, he proceeded as follows:—

'Dry subchloride of thallium was introduced into fused bisulphate of soda, which readily converted it into sulphate of thallium. The fused mass was dissolved in water, and the thallium precipitated in the metallic form by chemically pure zinc.'

On a large scale the process was thus carried out:—

'Three large spirit casks were so placed that the liquid in the upper cask could be emptied into the lower one by means of a syphon. In the upper cask the fine dust was lixiviated by means of water warmed by steam. The clear concentrated liquor syphoned off into the second cask, and the sulphate of thallium precipitated as chloride of thallium by hydrochloric acid. The second extract in the upper cask was used as the solvent in the next charge. After the liquid had been drawn off, the second cask was filled with pure water and a sufficient quantity of crystallised sulphate of soda. By agitating, the conversion soon takes place; the liquid is brought to the second cask, acidulated with sulphuric acid, and the thallium precipitated with pure zinc. The sponge thallium is washed with water, pressed, and fused.'—DINGLER'S *Polyt. Jour.*, clxvii.

The following method of obtaining thallium from the soot of sulphuric acid works has been devised by Herr STOLBA. In repeatedly working up the soot of two sulphuric acid works in Germany, where pyrites from Meggen were used, a method was employed in separating the thallium which depended upon a formation of a thallium alum. The soot is first passed through a coarse sieve to remove the pieces of brick, mortar, and clay mixed with it, and then boiled in water acidified with sulphuric acid. It is next placed on a suitable filter and stirred, while carefully washed with hot water until all the acid is removed. The wash-water, after acidifying, can be used for boiling a second portion in, and so on. The first filtrate, which is tolerably concentrated, is evaporated in very shallow dishes to such a degree as to crystallise. Beautiful large reddish crystals of thallium-alumina-iron alum are formed as it cools. To the mother liquor was added some sulphate of alumina, and again evaporated, when a small quantity of mixed alums separated. The last mother liquor, as well as the rinsings from the crystals, when precipitated with crude hydrochloric acid, yielded a surprisingly small quantity of chloride of thallium.

The crystals of thallium-alum were recrystallised twice from water containing sulphuric acid. The alum thus obtained was so pure that it yielded pure thallium when acted upon by pure zinc and pure sulphuric acid, and with a pure hydrochloric acid pure chloride of thallium was precipitated.

The crude chloride of thallium may be prepared in the usual manner, and next converted into sulphate by means of sulphuric acid, and finally, by means of sulphate of alumina, into thallium alum, which can be purified by recrystallisation. The first method is, however, more convenient, because it does not involve the troublesome decomposition of the chloride by means of sulphuric acid. As the thallium alum is considerably more soluble in hot than in cold water, the conversion of the much less soluble sulphate into the more soluble alum offers the great advantage that the latter can be recrystallised from a much smaller quantity of water, which is more convenient and requires less time. Besides this, the alum is a compound easily converted into the chloride or iodide, from which the metal is easily obtained.

If an aqueous solution of fine-dust is precipitated with hydrochloric acid, a portion of the metal still remains in solution.

The addition of a solution of iodide of potassium without previous reduction of the ferric salts to the filtrate from the chloride of thallium precipitate, throws down the whole of the metal in the form of a brownish-black iodide. When this iodide is boiled with sulphide of sodium, sulphide of thallium is produced, while iodide of sodium goes into solution.

The sulphide of thallium is dissolved in dilute sulphuric acid, and the metal precipitated by an electric current.—R. NIETZKI, *Arch. Pharm.*, vii.

Thallium and Tin, exposed on charcoal to the reducing flame of a blowpipe, exhibit the same reactions as lead and tin; but the cauliflower-like excrescences are brownish-black.—CHAPMAN, *Philosophical Magazine*, December, 1876.

Thallium Chlorate. (See WATTS'S *Dictionary of Chemistry*, vol. v.) Mr. JOHN MUIR says this salt is easily obtained by mixing equivalent quantities of sulphate of thallium and chlorate of barium, and filtering from the sulphate of barium, and concentrating the solution. (See *Journal of the Chemical Society*, June 1876; and consult also the *Isometric Relations of Thallium*, by T. E. THORPE, F.R.S.)

THERMOMETER. (Vol. iii. p. 989.)

Thermometer of Translation, or Integrator of Variation of Temperature.—This instrument was designed by Mr. THOMAS STEVENSON, C.E., of the Scottish Meteorological Society. A bar of zinc is fixed at its lower end during expansion by the needle points catching in the teeth of the rack below, so as to produce lengthening upwards, while during contraction the bar is held by the needle at the top, so that the shrinking is upwards. In this way the centre of gravity is moved upwards. The total annual march or creep of the bar will measure the total amount of fluctuation of temperature.

Continuous Self-registering Thermometer, the Invention of Mr. W. HARRISON CRIPPS.—The object of the instrument is to obtain a continuous registration of heat. The instrument is in two portions—first, the thermometer for indicating the temperature; secondly, the clockwork for registering the hours and minutes. The thermometer consists of six coils of glass tubing wound concentrically round an axis in such a manner as to form a spiral glass wheel 4 in. in diameter. The last coil is moved slightly away from the others, so that it shall form the circumference of a circle 5 in. in diameter. To each end of the axis a fine needle-pointed pivot is attached. These pivots rest on minute depressions between two parallel metal uprights. By this arrangement the glass wheel can rotate freely between the uprights. The spirit in the thermometer fills the spiral portions of the tube, and also 3 or 4 in. of the last coil (the one forming the circle). The spirit then comes into contact with a column of mercury 4 in. in length. Beyond the mercury are a few drops of spirit to moisten the glass. The remaining portion of the tube is hermetically sealed, enclosing a small quantity of air. On the spirit expanding with heat, the column of mercury is driven forwards. This immediately alters the centre of gravity, and the wheel revolves in a direction contrary to that of the moving mercury. When the spirit contracts on cooling, the enclosed air, acting as an elastic spring, keeps the mercury in contact with it, and the wheel regains its original position. By this arrangement the two forces, heat and gravity, acting in contrary directions, generate a steady rotary motion.

The method by which this movement is made serviceable is by a grooved wheel 2 in. in diameter fixed to one of the pivots, and therefore revolving with the thermometer. Fixed to and passing over this wheel is a fine thread, from which is suspended a pencil-holder, moving up and down on a vertical slide. The pencil will be raised or lowered according to the direction in which the wheel is moving. The other portions of the clockwork are arranged in a manner similar to that employed in the barograph.

In the instrument a cylinder $4\frac{1}{2}$ in., both in width and diameter, is made to revolve once in seven days. Around this cylinder is placed a paper, on which the days and hours are indicated by vertical lines. The cylinder is so placed that the surface of the paper is $\frac{1}{16}$th of an inch away from the pencil-point, moving at right angles to its surface. A small striker is connected with the clockwork in such a manner that at every quarter of an hour it gives the pencil a tap, striking its point against the paper.

Deep Sea Thermometer.—This instrument is like a syphon with parallel legs. At the bottom of the left-hand tube is a small glass plug. The mercury rises or falls as in an ordinary thermometer; but, at the moment the temperature is desired to be recorded, the thermometer, by a kind of vertical propeller, is made to pivot on its centre, causing the mercury to break off at the plug, and to pass into the right leg, where it remains fixed, indicating the exact temperature. The bulb is protected from

water pressure by an outer covering of thick glass, the intervening space being nearly filled with mercury.

WILSON'S *Chrono-thermometer for Testing Mineral Oil.*—In the determination of the flashing points of mineral oils by the method prescribed by the Petroleum Act, it has been found that the rate at which the heating of the oil proceeds has an important influence upon the results. This is a point which the Act does not take cognisance of otherwise than by specifying that the source of heat is to be 'a small flame,' and accordingly most operators have fixed for themselves, and carefully adhered to, some arbitrary rate of heating in order to secure results which should be uniform and strictly comparative.

Thus in the testing-room of the Petroleum Association it is the invariable practice to raise the temperature of the oil at the rate of 20° in 15 minutes, this being, in the opinion of those who have been consulted by the Association on the subject, a fair and proper interpretation of the spirit and letter of the law. The time is noted when each sample of oil under examination reaches a temperature of 70°, and the lamp is so regulated that the oil arrives at a temperature of 90° in a quarter of an hour, this rate of heating being maintained until the termination of the experiment.

It will be obvious that such regulation involves constant reference to the watch or clock, especially where several samples are being tested at the same time, and necessitates considerable care and attention, as well as some little skill and experience, for some period before the actual testing of the oil commences.

To facilitate the operation, and at the same time to bring about the adoption of a uniform rate of heating, so as to minimise the discrepancies between the results of different manipulators, this little instrument has been devised.

A very few words will suffice to explain the instrument. It consists of a watch movement, in conjunction with a circular thermometer; and measuring as it does simultaneously both time and temperature, the inventor has very aptly christened it a 'chrono-thermometer.'

The watch is provided with but one hand, and the balance wheel is so adjusted that this hand moves through 20° of the thermometer scale in 15 minutes. It is, therefore, merely necessary in making an experiment to set the hand when the mercury reaches 80°, and to regulate the lamp so that the quicksilver and the watch hand travel round the dial *pari passu*. If the thermometer is observed to be getting ahead of the watch, the light under the water bath is slightly lowered (this being easily effected by the mechanical arrangement in the wick holder), and, of course, *vice versâ*.

The scale of the thermometer and the size of the bulb are strictly in accordance with the Act of Parliament, the rest of the apparatus being of the ordinary Parliamentary model. The inner line of degrees marked on the thermometer scale represents minutes (1 to 15), and the other line degrees of FAHRENHEIT'S scale, 20 of which (80 to 100), it will be observed, are equivalent to the 15 minutes—though, of course, in the construction of the instrument any other desired rate of heating may be provided for.—BOVERTON REDWOOD, F.C.S., Consulting Chemist to the Petroleum Association: *English Mechanic.*

THICKENINGS. Substances used by the calico printer and dyer for thickening the colours to be used in printing, or for adding to the weight of the fabric in the process of dyeing. They are either mineral or vegetable, the former being kaolin and pipe clay, the latter generally starch, cellulose, and a substance called suberine.

THUYIN. A yellow colouring matter extracted from a well-known coniferous tree, *Thuya occidentalis.* On being boiled with sulphuric acid it is split up into an amorphous sugar and *thuyetin.*

$$\underbrace{C^{20}H^{22}O^{12}}_{\text{Thuyin}} + 2\,H^{2}O = \underbrace{C^{6}H^{12}O^{6}}_{\text{Sugar}} + \underbrace{C^{14}H^{14}O^{8}}_{\text{Thuyetin}}.$$

KAWALIER, *Comptes Rendus de l'Académie de Vienne*, vol. xxix. 10.

THYMOL. $C^{10}H^{14}O$. Thymol is obtained from thyme oil by fractional distillation; it is also obtained from the volatile oil of horsemint, and also from *Ptychotis Ajowan.* See WATTS'S *Dictionary of Chemistry.* See HAÏ-THAO.

THYMOL COLOUR. M. C. LIEBERMANN, in a paper on the colouring matters obtained from aromatic oxy-compounds and nitrous acid, gives the following in *Comptes Rendus*, No. 24, 1874:—'Ten grams of thymol in fine powder, 10 grams of sulphuric acid, and 40 grams of the reagent are employed, and the nitrous acid must be added immediately after the mixture with the sulphuric acid. The solution is first

green, and then blue. The disengagement of gas must be prevented. A double volume of sulphuric acid is then added, and the whole allowed to stand for some hours. It is then precipitated by being poured into an excess of water, filtered, and perfectly washed. There remains a violet resinous mass, soluble in alcohol, with a fine violet-red colour.'

TILLANDSIA USNEOIDES. See LONG MOSS.

TIMBER, PRESERVATION OF. M. BOULART, in the *Annales Industrielles*, after describing the various processes, now well known, for the preservation of timber by artificial means (which, it is said, originated in France), gives an account of the method pursued by M. HATZFELD, which differs from all its predecessors. He has ascertained that the woods most resistant to decay are those which are richest in tannic and gallic acids; thus the oak, which furnishes almost all the tan in general use, is of indigenous woods the most durable, whether immersed in water or buried in earth. These properties of oak will be understood when its composition is considered. It contains essentially the elementary cellular tissue of all those vegetables which deposit lignite, forming a hard concretion predominant in resistant woods, as ebony. Oak and similar woods are saturated with a sap containing gummy and azotic substances and colouring matters. The sap of oak contains a notable quantity of tannic acid, which probably acts upon the vegetable tissue of its timber in a manner analogous to that in which tan acts upon animal tissue, with which it forms an insoluble compound. The hardness and colour acquired by oak after being buried for long periods are due to the tannate of peroxide of iron formed by the combination of tannic acid with ochres or salts of iron, existing in more or less considerable quantities in divers earths; and this tannate of peroxide of iron (an essentially insoluble salt) ought to play the same part as the lignite, of which it artificially augments the quantity. M. HATZFELD therefore proposes for the preservation of various woods impregnation with tannic acid, which gives to the wood the durability of oak. He then proposes to inject a solution of pyrolignite of iron, which in the cells becomes gradually tannate of iron, making the wood similar to oak which has been long buried and has become hard and unalterable. The liquid for injection should be a mixture in water of a tanniferous substance and a salt of protoxide of iron.

'The most advantageous tanniferous substance is an extract of the chestnut, costing about 3*d*. per lb.; and the most convenient salt of iron is pyrolignite of iron (20° B.), costing 10·8*d*. per gallon.

'According to analyses of these materials, and by analogy with the sulphate of copper processes (described at length), to obtain a solution containing 1 per cent. of pure tannic acid and 1 per cent. of tannate of protoxide of iron, there would be necessary per 22 gallons of liquid, or for four sleepers, 7·7 lb. of dry extract of chestnut, containing 60 per cent., or 4·62 lb. of tannin; 3·52 pints of pyrolignite of iron, containing 2,037 grains of iron and 2·2 lb. of tannin, the cost thus being 6·5*d*. to 7*d*. per sleeper, which is but slightly in excess of the cost by the sulphate of copper process. It is pointed out, however, that tannic acid being widely diffused in the vegetable kingdom, the above preserving liquid, if manufactured on a large scale, could be produced by a direct process at a much lower cost.

'Preservation by superficial carbonisation is then considered, particularly with reference to M. LAPPARENT'S gas method. The burners used are those commonly known as "atmospheric," but of large size. As soon as the wood is strongly blackened it is sufficiently carbonised, for the film of charcoal need not be more than $\frac{1}{25}$th in. in thickness. The charred part of the wood, which is easily detached, does not resist decomposition, but the browning of the film underneath, while destroying the spores of fungi, hardens the surface and makes it somewhat horny and slightly impregnated with creosote or tarry matter, which prevents their growth. One man can carbonise 10 sq. ft. in five minutes, and should be able to do easily 1,000 sq. ft. per day of ten hours.

'M. HUGON, of Paris, has designed apparatus, more particularly for carbonising the surface of sleepers, at a greatly reduced cost.'—L. BOULART, *Annales Industrielles*, 1876; translated in the *Abstracts of Foreign Papers* of the Institution of Civil Engineers.

TIN. The summary of the production of the tin mines of Cornwall and Devonshire will be found under MINERAL STATISTICS, p. 573. It appears desirable, however, to give here a little more in detail the production of tin in districts and countries.

It should be noted that, owing to the large supply of tin from the Dutch Settlements and from Australia, the variations in the price of tin ore have been very great. In 1872 the price of tin ore in Cornwall was 87*l*. 7*s*. a ton; in 1874, 56*l*. 3*s*. a ton; in 1876, 43*l*. 18*s*. a ton; and in 1877 and 1878 the price has been so low as 35*l*. 10*s*. a ton.

Produce of the Tin Mines, Stream-works, and Rivers, &c., of Cornwall and Devonshire, as returned to the Mining Record Office, to the Stannary Court, and to the Duchy of Cornwall in 1876.

	No. of Mines, &c.	Quantity of Black Tin				Value of Black Tin			Metallic Tin, estimated
		Tons	cwt.	qrs.	lb.	£	s.	d.	Tons
CORNWALL:									
Western District	17	2,097	1	3	14	89,134	2	6	
West Central District	72	8,407	3	2	15	365,138	7	0	
East Central District	11	700	0	1	26	31,675	11	1	
Eastern District	4	901	17	0	24	37,225	4	6	
DEVONSHIRE	6	47	16	0	23	2,107	17	4	7,859 0 0
Tin sold in stone in both counties — Returned	10	605	17	0	0	20,305	5	11	
Tin sold in stone in both counties — Estimated		100	0	0	0	4,000	0	0	
Tin from streams, rivers, and foreshores in both counties	15	780	8	1	12	26,017	16	8	
	135	13,640	4	3	2[1]	575,604	5	1	7,859 0 0

The Inspector's return for Cornwall and Devonshire is 12,679 tons, but the returns from tin-streams, fore-shores, &c., is not included in this quantity.

The importance of the production of tin in the Dutch East Indian possessions, especially at a time when the Cornish tin miners are suffering so severely from the large quantities of tin brought into this country, renders it important that the statement of the Dutch sales should be recorded up to the latest date:—

DUTCH TIN.

Deliveries of Banca Tin in Holland.

	Slabs
1876	132,033
1875	126,436
1874	123,633

Sales of Banca Tin in Holland by Dutch Trading Company in 1876.

	Slabs	Average price per 50 slabs.[2]	
January 26	14,216	50	florins
March 29	7,300	50	"
May 31	29,317	46·50	"
July 26	29,881	43·25	"
September 26	29,677	42·75	"
November 29	29,611	46·60	"
	140,202		

Sales of Billiton Tin in Batavia in 1876.

	Picals.	Average price per picul.	
February 14	10,000	53	florins
April 10	10,000	$50\frac{1}{8}$	"
June 12	10,000	$47\frac{1}{2}$	"
August 14	10,000	46·42	"
October 9	10,000	45	"
December 11	10,000	48·72	"
	60,000		

[1] A small portion of this will be derived from tin ore stocked in 1875.
[2] 1,000 Banca slabs weigh about 32 tons.

The following figures give the supply of tin for each of the last five years:—

	1877	1876	1875	1874	1873
	Tons	Tons	Tons	Tons	Tons
English production	7,800	8,500	9,014	9,942	9,970
Banca sales	4,456	4,519	4,400	4,040	4,355
Billiton sales	3,643	3,043	3,526	3,157	2,950
Straits' shipments . . .	7,200	9,521	11,300	7,677	6,063
Australian arrivals . . .	8,890	7,130	7,218	3,800	2,950
Total . . .	31,989	33,313	36,057	30,525	27,258

From this it will appear that the Eastern Archipelago and Australia produced in 1876 no less than 26,000 tons of tin, and of this we received nearly 16,000 tons, when our own native production of tin was less than 8,000 tons.

The following table (see page 900), with which we have been favoured by Messrs. Von Dadelszen and North, will show the progress of the foreign tin trade for several years.

Australian.—Some further notices of the tin ground of Australia and Tasmania cannot be without interest.

New South Wales.—The principal tin veins in New South Wales which have yet been worked occur in granite similar to the stanniferous granite of Cornwall. In some parts, as at Elsmore and Newstead, New England, much of it occurs in veins of greisen (mica and quartz), and in eurite (felspar and quartz). At Newstead mine, and also at the Albion tin mine, crystals of tin-stone are seen disseminated through large and well-formed transparent quartz crystals. At the former place the quartz crystals in which it occurs often weigh nearly a hundred-weight.

It occurs in association with molybdenite, fluorspar, a yellow steatitic mineral, garnet, beryl, topaz (the matrix of the tin-stone is sometimes in places composed solely of topaz), malachite, copper and iron pyrites, mispickle, tourmaline or schorl.

The alluvial deposits are extensive. Up to the present time (1876), most of the tin has been obtained from the New England district.

Rolled *wood tin* of a grey and black colour occurs at Abington; also at Grenfell, with extremely well-marked concentric and radiate structure, composed of red, brown, and black bands, other fragments made up of alternate light and dark-grey bands.

The principal localities are the following:—The Undercliff and Bookookoorara, in county Buller; Tea-tree Creek, tributary of Omeo River; Michell and Henry Rivers (county of Gresham); Gordon's Creek, Glen Creek, Ranger's Valley, Shannon River, Severn River, Paradise Creek, Sheep-station Creek, Spring Creek, Stockyard Creek; Swan Creek, near Inverell; Yarrow River, Middle Creek, Auburn Vale Creek, Cope's Creek, Sandy and Moredun Creeks, tributaries of the Bundarra, Kentucky Ponds, Honey's Creek, Honeysuckle Creek, Gwydir and Rocky Rivers, Sandy Creek, Warialda Creek, Myall and Reedy Creeks; Bald Rock; Nangahra, Tiabundie, and Mount Lowry Creeks; Maryland and Herding Creeks; Boonoo Boonoo; Mount Michell and Oban, Sara and Ann Rivers, Uralla, Carlyle Creek, Deepwater, Mole River, and Sandy Mount; Bendemeer in greisen; Quirindi and Carroll's Creeks; Turon River, Shoalhaven River, Long Gully and Spring Creek, near Bungonia, Burra Creek, county of Selwyn; Dabarra, Jingellic Creek; at Mowembah in quartz associated with chalcedony. Vein tin occurs in quarries at Billabong, near Wagga-Wagga. Rolled wood tin, with the diamonds, near Mudgee and Bathurst; Tumberumba, with gold.

Tin amount of tin raised in New South Wales from 1872 to the end of 1874 was valued at 866,461*l.*

The Mines and Mineral Statistics of New South Wales in 1875, compiled by direction of the Minister of Mines, says:—

'That large quantities of stream tin have been raised at Cope's Creek, Tingah, is well known, but whether the subjoined statement embraces all the tin ore that has been raised is more than doubtful.

'During the year 1874 the quantity and value of the tin ore won in the Maryland district is said to be—

	Tons	Value
Maryland	2,162	£107,000
Mole table land	246	14,032
Total	2,408	£121,032

There is no record of the tin ore raised in the southern part of this colony during

Statistics of Foreign Tin from the Spring Sale, 1868 to 1876.

Years	April	May	June	July	August	September	October	November	December	January	February	March	Years
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	
1868 Tin in stock .	6,095	5,774	6,602	4,008	4,870	4,315	7,407	6,448	6,408	4,013	4,115	3,918	1869
" on the way	4,422	4,606	4,001	6,492	5,830	6,725	2,574	2,143	2,014	3,347	3,347	3,862	
	10,517	10,380	10,603	10,419	10,700	10,440	9,981	8,081	8,500	8,060	7,600	7,180	
1869 Tin in stock .	3,879	4,817	4,942	4,026	4,609	4,107	6,144	5,448	4,817	4,108	3,740	3,299	1870
" on the way	4,003	2,705	3,144	4,200	4,000	4,570	2,944	3,611	3,844	4,595	5,271	5,940	
	7,882	7,522	8,086	8,185	8,610	8,683	9,088	9,059	8,661	8,703	9,011	9,239	
1870 Tin in stock .	4,913	4,036	4,000	3,471	3,010	2,680	3,077	4,488	3,743	3,337	2,892	2,710	1871
" on the way	3,423	3,632	4,330	4,626	6,081	6,108	4,100	3,787	4,347	4,700	5,193	5,889	
	8,336	7,668	8,330	8,097	8,090	8,788	8,182	8,275	7,990	7,037	8,085	8,599	
1871 Tin in stock .	4,983	5,036	4,728	3,653	2,734	2,741	4,868	3,925	3,007	3,501	3,812	3,600	1872
" on the way	4,413	4,336	3,763	3,970	4,424	4,388	3,098	2,133	1,973	3,673	3,722	3,109	
	9,396	9,370	8,491	7,623	7,158	7,129	7,961	6,058	4,974	7,174	7,534	6,617	
1872 Tin in stock .	4,821	3,681	3,630	2,944	3,112	2,880	4,231	3,289	3,651	3,426	2,100	1,631	1873
" on the way	1,778	3,190	3,273	3,244	4,030	4,084	3,444	3,343	3,686	3,920	4,712	5,446	
	6,599	6,871	6,903	6,188	7,131	6,964	8,677	6,632	6,317	6,402	6,812	7,137	
1873 Tin in stock .	3,691	3,688	3,894	3,790	2,391	3,007	4,137	3,138	3,600	3,604	4,299	3,673	1874
" on the way	3,367	4,757	5,132	5,472	7,040	6,104	4,700	5,264	5,150	6,254	6,028	6,152	
	7,058	8,450	9,018	9,271	9,431	9,201	8,900	8,393	8,733	9,748	10,327	9,824	
1874 Tin in stock .	3,631	4,084	4,831	4,064	4,261	3,883	4,489	4,180	4,603	4,307	3,694	6,204	1875
" on the way	7,504	7,076	5,993	6,113	7,072	6,071	7,183	7,266	6,544	7,421	8,192	7,010	
	11,135	11,160	10,824	10,177	11,333	10,024	11,672	11,441	11,157	11,728	12,186	13,214	
1875 Tin in stock .	7,148	7,480	7,673	7,300	7,374	6,774	7,853	7,107	7,404	7,797	7,997	8,851	1876
" on the way	5,838	6,308	5,381	5,298	6,412	6,872	5,233	5,571	4,863	6,346	6,063	6,047	
	12,986	13,868	12,964	12,601	13,786	13,646	13,066	12,678	12,267	14,143	14,060	14,898	

1874 except that the Pullstop company, near Wagga-Wagga, raised 1,200 lb., value 40*l*. The bulk of the tin from Maryland and some other fields in the North is sent into Queensland, and that raised in the South into Victoria.'

Tin, the Produce of the Colony of New South Wales.

Year	Tin Ingots		Tin Ore		Total Value
	Tons	Value	Tons	Value	
1872	47	£6,482	648	£41,221	£47,703
1873	904	107,795	3,635	226,641	334,436
1874	4,101	336,182	2,118	118,133	454,322
	5,052	450,460	6,401	385,995	836,461

TASMANIA.—T. H. WINTLE, Esq., of Hobart Town, communicated to the Royal Society of New South Wales a paper on the 'Stanniferous Deposits of Tasmania,' from which the following notes are taken:—

'Mount Bischoff, the most important of the tin-bearing districts, is situated about midway between the north-west coast and the west coast of Tasmania, with Bass's Straits on the one hand and the Pacific Ocean on the other. Were a line drawn from Emu Bay to about midway between Macquarie Harbour and the mouth of the Pieman River, it would bisect Mount Bischoff, and thus form a base line of a nearly equilateral triangle with Cape Grim.

'Mount Bischoff has an altitude of 3,500 feet (GOULD says 2,500 feet) above the sea, and but little more than 1,000 feet above the basaltic table-land; the ascent being more or less gradual from the coast. It consists of eruptial euritic porphyry, which forms a crescent-shaped ridge on the summit, the extremities of which ridge are not more than a quarter of a mile apart, the intervening space being a horseshoe depression or basin. It is here that the richest deposits of tin ore exist. This basin looks south, and presents a natural outlet to the surrounding table-land, while the northern and western slopes are exceedingly steep, presenting a mean angle of descent of 35 degrees. The porphyry is the chief matrix of the tin ore. It has burst through the transition strata which repose on the slopes of the mountain, displacing, contorting, and folding them in a most fantastic fashion. These strata chiefly consist of clay-slate, sandstone, and quartzose rock; the former being frequently highly charged with sulphides of iron and tin. The tin ore occurs as a binoxide, and traverses the porphyry in veins and lodes, the breaking up of which by subsequent eruptive forces scattered the tin ore on the slopes of the mountain in the form of talus. The transporting and arranging power of water as a mechanical agent seems to have played no part whatever in these stanniferous deposits, inasmuch as the particles and nuggets of the ore afford no evidence of having been subjected to attrition, but, on the contrary, display sharp, irregular edges. The disruptive force which shattered the lodes was probably the same as that which affected the vast basaltic flow of the surrounding country. The ore is not generally distributed over the sides of the mountain, but exists in local patches of limited extent in the majority of instances. In earnest of this may be mentioned that on Messrs. WALKER and BEECRAFT's section, 240 tons of ore were taken out of a chain square of wash-dirt, while at a distance of about twenty yards on either side of the cutting barely a trace of the ore could be obtained. Some of the masses or nuggets of ore taken out of the wash-dirt on this claim, or from between loose, fallen masses of porphyry, weighed as much as 6 cwt. Not a few of these masses were almost entirely free from the matrix. It seems somewhat remarkable that although there are strong evidences of the existence of lodes in the immediate neighbourhood of these tin ore deposits, only one actually well-defined lode has been laid bare. It must be remembered that during the two first years of working, not half an acre of wash-dirt was removed, then this apparent anomaly is somewhat modified. Evidences of shattered walls of tin lodes are daily brought to light. In a hole sunk to a depth of 20 feet, and about 30 yards in advance of the face of the excavation, large masses of tin ore lie so thickly embedded in a cement-like matrix that recourse has been had to the mall and wedge to remove them.

The eminent geologist and mineralogist of Victoria, Mr. ULRICH, joins issue with Mr. WINTLE respecting the existence of actual lodes of tin ore at Mount Bischoff. His opinion was that the tin ore occurred in the porphyry as 'bunches.' Since then the lode on the WARATAH COMPANY's claim has been discovered, and most of the other evidences of their existence in other parts brought to light. In the associated sedi-

mentary strata, numerous crevices and joints are found filled with cassiterite, but these are generally too small to have any value. The depth of the stanniferous drift varies from one foot to thirty feet, the greatest depth being as a rule on the steepest slopes.'

George Bay, on the east coast of Tasmania, was visited by Mr. WINTLE in October, 1874. He says:—

'At the head of a rivulet, the source of a fine stream known as the Golden Fleece, I discovered tin ore in highly payable quantity extending over considerable area. This locality forms the scene of operations of the RUBY TIN MINING COMPANY, and is only five miles from the place of shipment at George Bay. More recent discoveries show that the tin-ore bearing country obtains at a greater distance in a north-westerly direction, as, for instance, at Boobyalla, Mount Cameron, Mount Horror, and in the Ringarooma district, or Gould's new country. Scarcely a day passes without tidings of fresh tin ore discoveries being made in this part of the island.'—See *Note upon a Recent Discovery of Tin Ore in Tasmania*, by CHARLES GOULD. *Quarterly Journal of the Geological Society*, vol. xxxi. p. 109.

Mount Ramsay is about ten miles from Mount Bischoff, and is named after Professor RAMSAY, of the Geological Survey of the United Kingdom. Mount Ramsay is essentially composed of a coarse tourmaline granite occasionally passing into a fine grained rock. This granite rises in three bold lofty peaks. Unlike Mount Bischoff, the older palæozoic strata are seen only around the base. The creeks and gullies furnish very superior ruby tin ore, associated with considerable quantities of zircon sand and tourmaline; but the tin occurs in much less quantity than at Mount Bischoff, and until about two years ago the best seldom reached an ounce to the tin dish. Since that time, however, very promising indications of lodes have been found, consisting of rounded nuggets of nearly pure binoxide of tin, varying from the size of a marble to a hen's egg. These have been followed up till portions of lodes have been obtained showing very little sign of abrasion.

The following detailed statement of the imports of tin in 1875 and 1876 shows that there is a slight falling off in the quantity of foreign tin reaching this country. It must, however, be noted that some quantities of tin have been produced in those years in Siam and in Burmah; much of this has been used in those countries, and some of it has gone to China, thus interfering to some extent with our export trade.

Imports of Tin as per Parliamentary Returns in the Years 1875 and 1876.

Countries from which Imported	1875		1876	
	Tin Ore	Tin, Blocks, Ingots, Bars, and Regulus	Tin Ore	Tin Blocks, &c., and Regulus
	Tons	Tons	Tons	Tons
Germany	—	—	—	32
Holland	1	467	—	314
France	6	7	22	—
Portugal	3	—	—	—
Channel Islands	—	5	—	—
Cape of Good Hope	—	115	—	—
Ceylon	—	21	—	—
China	—	6	—	—
British India	—	98	—	25
Straits Settlements	26	8,566	—	7,538
Australia: Victoria	42	1,197	—	1,334
" New South Wales	18	4,747	3	5,231
" Queensland	—	377	—	409
" Tasmania	—	30	75	181
" South Australia	—	262	—	—
Peru	296	202	224	78
Bolivia	—	20	4	10
Chili	—	58	11	29
Other Parts	—	4	3	8
Total	391	16,788	342	15,228

JAPAN.—Tin exists in Japan, but it has not been much sought after, and not much is known about the quantity or quality. There are small mines in Bango and Sat-

mma, also in Sarro on the main island, but the total production in 1874 was seven tons and a half.

TUSCANY.—At a meeting of the Paris Society of Civil Engineers a paper was read on a discovery said to have been made in Tuscany of a vein of bioxide of tin. The vein is reported to be situated about a mile and a quarter south-west of the town of Campiglia Marittima, in Tuscany, at a place called Cento Camerelle, upon the western side of the Fumacchio, a spur of the Monti Calvi, a chain celebrated for its mineral deposits. The Cento Camerelle (Hundred Chambers) consists of a series of excavations attributed to the Etruscans, and dug out horizontally in the side of the mountain. The concretions with which they were filled have been removed in the course of ironstone mining. The tin was stumbled upon some mètres from the Cento Camerelle in following up a vein of brown hæmatite. The tin ore is very compact, of a yellowish-grey colour, and of granular fracture. Specimens yielded from 55 to 72 per cent.

TIN PLATE. (Vol. iii. p. 1011.) In 1876 about 68 firms were engaged in the manufacture of tin plate in this country. The following were the returns given in the 'Mineral Statistics' for 1876, of the state of the manufacture in that year:

The returns received from tin plate works have been as follows:—

Number of boxes of tin and terne plates . . .	1,406,229
Ditto black plates	240,047
Total number of boxes . . .	1,646,276

Actual weight of the whole returned, 85,472 tons.

The tin plate works which have not made returns are estimated as follows. In the estimation of these I have been greatly assisted by gentlemen who are connected, and intimately acquainted, with the tin plate manufacture:—

	Boxes
Total estimated number of boxes of tin and terne and black plates	1,170,117
Actual number of boxes of tin and terne and black plates returned as above	1,645,276
Total number of boxes of tin, terne, and black plates made in the United Kingdom in 1876 .	2,815,393

Canada Plates.

	1872	1873	1874	1875	1876
	Boxes	Boxes	Boxes	Boxes	Boxes
From Liverpool .	31,610	29,863	35,010	38,880	33,352
" London . .	—	1,300	—	—	—
Total Boxes .	31,610	31,163	35,010	38,880	33,352

For Exports of Tin Plates, see p. 904.

A method of recovering the tin from tin-plate scrap by electricity has been recently introduced with considerable prospect of success. Mr. N. S. KEITH, of Brooklyn, New York, has, by means of a series of experiments, ascertained that by means of electricity the tin can be removed from tin-plate scrap, and the separation and recovery of the tin and iron can be effected with great rapidity. The scraps are moved progressively through a liquid electrolising bath, while under the action of electricity and the solution of the bath, and if subjected at the same time to a heat of not less than 160° Fahr., the tin may be dissolved and removed without material solution or oxidation of the iron which forms the body of the scrap. The vat used for the bath should be of a material which is a good conductor of electricity; and the solution must be such as will dissolve the tin when excited by electricity: a solution containing a quantity of free alkali, such as caustic potash or caustic soda, is preferable. The vat must be connected with a galvanic battery in such a manner that the scrap constitutes the anode, and the vat the cathode for the current. Scrap tin-plate appears in the market in a curled and tangled condition, and it was found that if subjected to the liquid electrolising bath in this condition, the free surfaces of the curls were immediately acted upon, but that the parts where the curls overlapped one another, or where any part of the tinned surface was covered, that the covered part was scarcely affected at all, so Mr. KEITH found it necessary to straighten the scrap before immersing it in the bath. The most successful solutions are the

Statement of Tin Plates exported from United Kingdom to all Ports, Year ending December 31, 1876.

	Liverpool	London	Southampton & Newhaven	Swansea	Hull	Glasgow	Newcastle	Bristol	Cardiff	1876	1875	1874	1873	1872
	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes	Boxes
United States Ports . . .	1,426,120	4,760	55,201	—	—	—	—	123,344	—	1,600,515	1,673,435	1,685,994	1,511,632	1,531,356
Holland, Germany, and Belgium .	31,586	105,566	—	669	1,757	—	—	1,617	68	140,165	129,114	90,313	63,847	83,902
Australia and New Zealand .	11,377	58,405	—	—	—	—	—	—	—	69,782	52,655	42,394	76,890	82,666
Italy and Mediterranean . .	85,993	11,021	—	365	—	—	—	—	—	97,370	121,348	72,990	114,099	70,086
Canada and Brit. North America .	92,005	1,500	—	—	—	1,070	—	110	—	95,634	79,022	66,188	60,319	72,630
France and Switzerland . .	12,266	8,447	3,897	84,050	—	—	—	—	119	108,752	63,455	40,318	71,589	59,973
South America and Brazils . .	40,299	4,118	7,344	—	25	100	—	—	700	52,580	54,161	51,079	50,832	50,989
Spain and Portugal . . .	36,000	2,101	—	22,791	—	—	—	—	109	60,904	72,174	54,013	64,041	48,810
Norway, Sweden, and Baltic .	6,010	63,621	—	30	8,481	—	5,001	—	—	83,233	114,993	71,555	67,630	48,555
India and China . . .	18,935	42,122	—	—	—	700	—	—	—	61,703	71,897	44,636	42,515	14,606
West Indies . . .	6,877	3,226	—	—	—	40	—	—	—	10,143	8,847	8,053	8,434	6,292
Cape, Ceylon, and Mauritius .	—	3,332	862	27	—	—	—	—	—	4,261	2,916	3,111	7,984	5,329
Africa and Unclassed Islands .	434	2,651	20	703	—	—	—	111	—	3,919	4,261	4,169	3,038	2,288
Unclassed and Unreadable . .	1,310	473	—	—	—	50	11	—	—	1,862	1,690	1,755	1,199	286
Total Boxes, 1876 . .	1,760,313	310,372	67,434	108,615	10,263	2,875	5,102	125,082	963	2,400,036	—	—	—	—
Total Boxes, 1875 . .	1,806,737	327,800	96,785	65,487	10,018	3,472	2,470	107,883	18,734	—	2,448,986	—	—	—
Total Boxes, 1874 . .	1,497,440	231,263	107,087	41,456	19,562	4,128	1,836	110,471	130,224	—	—	2,143,468	—	—
Total Boxes, 1873 . .	1,565,019	251,806	117,010	73,077	12,560	8,059	615	63,392	41,946	—	—	—	2,153,477	—
Total Boxes, 1872 . .	1,597,689	223,502	102,876	82,710	10,469	16,508	892	41,117	5,159	—	—	—	—	2,083,451

following—Caustic soda, 3 lb., nitrate of soda 1 lb., to every gallon of water contained in the vat; or caustic potash, 3 lb., nitrate of potash 1 lb. to every gallon of water; or caustic soda 1·5th lb. and common salt 2 lbs. to every gallon of water. The scraps are placed on the cross-bars of an endless chain of rods, which must be of such material as will allow the scraps to be in immediate electrical connection with the battery, and so moved progressively into, through, and upwards out of the bath. The tin is dissolved from the scraps and deposited in the vat as crystals of metallic tin; the tin thus recovered is removed from the vat, washed, and reduced to block tin or otherwise utilised as circumstances may require; and the iron, being thus cleansed from the tin, may be used as ordinary scrap iron. Mr. Keith does not confine himself to the use of one particular solution, but it is necessary to avoid any solvent that would act injuriously on the iron scrap: the solution is permanent, it being only necessary to replace water lost by evaporation; also to add occasionally such of the constituents as are unavoidably removed with the iron scraps. By this process much valuable metal which is now worthless may be again utilised at comparatively little cost.—*Mining Journal*, November 17, 1877.

Tin Scraps.—M. Kuenzel has published a very long article in the *Berg- und Hüttenmannische Zeitung* on the utilisation of the waste tin scraps. This article was carefully condensed in *Iron*, and from that excellent journal we borrow the following:—

'The mode employed comprises four chief operations—(1) treatment of the scraps by means of boiling in water acidulated with hydrochloric and nitric acid, until all the tin is dissolved; (2) precipitation by means of zinc of the tin contained in the above solution, and washing of the precipitate; (3) solution of the precipitated tin in hydrochloric acid, and crystallisation of the chloride of tin; (4) utilisation of the iron scraps when despoiled of the tin.

'1. Care in buying tin-plate scrap is one of the first essentials in a financial point of view. Good tin scraps contain from 5 to 9 per cent. of tin. Of course, the thinner the plate the greater is the amount of tin. French tin plate has 1½ to 2 per cent. more tin than English, as the plates are rougher, but it is very important to remember that the French tin is often, probably almost always, mixed with lead, a fact which may be ascertained by wiping the tinned article with a clean handkerchief, when, if lead be present, it will show itself. If the lead exceeds 10 per cent. of the tin, the scraps should be refused, as they are more difficult to treat, and leave the iron in a worse condition. Lacquered tin boxes, like those used for French sardines, give bad scrap, for the lacquer has to be destroyed by heat, which reduces the amount of tin recovered. Sometimes the scrap does not contain more than 2 to 4 per cent. of tin instead of 6 per cent., besides being mixed with lead. Galvanised iron (*fer zingué*) should also be rejected. When not packed, scrap tin is very difficult to carry, a ten-ton truck will not hold more than three to four tons; the best way, if possible, is to pack the scrap in old barrels or cases, and ram it down well. In France the scrap is made up into packets by being rammed into a wooden mould, rather broader at top than at bottom, and holding one or two cwt.; the packet is then fastened round with iron wire. The scrap thus packed must be well separated, or many pieces will stick together, and the action of the acid will be materially impeded.

'2. The solution used to dissolve the tin is composed of one part of raw nitric acid and ten parts of raw hydrochloric acid. At first wooden vats holding about three cubic mètres were used, but the acid destroyed them rapidly. The best vessels are those of stoneware, or vats of wood or of brick dressed inside with a hot mixture of one part of sulphur and two parts of sand. At the bottom of the vat, which should contain at least one mètre cube, a vulcanite pipe is introduced through which steam may be introduced from a boiler. The vat, or back, is nearly filled with scraps—a three-mètre vat will hold about 600 or 700 kilograms—the mixture of acids is then poured over the scrap, and water added to about four-fifths of the height of the scraps; the steam is then introduced till the solution completely covers the scraps, and is continued until the whole of the tin disappears from the upper scraps, and hydrogen ceases to be disengaged, showing that the solution has become neuter. The boiling takes generally about half or three-quarters of an hour. A cock at the bottom of the vat allows the liquid, which contains all the tin, a certain quantity of chloride of iron and of chloride of lead when the tin is not pure, to run off into a receiver into which nearly all the chloride of lead is precipitated by cooling. For the treatment of 1,000 kilos. of scraps, containing 5 to 6 per cent. of tin, the average quantity of acid employed is 300 kilos. of hydrochloric, and 30 kilos. of nitric, diluted with 3½ to 4 cubic mètres of water, of which a small quantity is used to wash the iron left in the vat, but which is saved for the next operation. The iron is then removed by means of forks, and made up into packets of various sizes, according to the purpose intended. These must not be kept in heaps, for they oxidise rapidly, and the heat thus produced will even heat them to redness. A heap of about 100 tons was once

burned in this way. For the treatment of three tons of scrap in twelve hours, six or seven vats, of about three cubic metres capacity each, are employed.

'3. The solution cooled in the receptacle already mentioned is now transferred to a large wooden or brick cistern, filled with old zinc-plate or scraps, which precipitates the tin, and also any lead which remains in the solution. This process should not produce any gas, as that would show the solution to have been too acid, and cause a useless loss of zinc. From time to time a small quantity of the solution, slightly acidulated by means of sulphuretted hydrogen, is tested to ascertain if the precipitation is complete. The operation is generally effected in two hours. When terminated, the solution is run off from the bottom, through a filter made of sailcloth, which stops any of the tin precipitate which may be floating, and the liquid is of no further use. The zinc is then moved about to cause as much of the tin as possible to fall to the bottom, and the solution from another boiling is then introduced. This operation is repeated until this vat or cistern is one-third or half filled with tin. About sixty-five to seventy-five parts of old zinc are required to precipitate 100 parts of tin. Theoretically, it should only require fifty-five parts, and the overplus must be attributed to an excess of acidity and to the oxides of zinc and lead generally present in the old zinc.

'The precipitate obtained, which is mixed with fragments of zinc and tin solder from the old zinc, is taken out of the vat and thrown on a metal sieve with holes about three or four 25ths of an inch in diameter, and a stream of water being directed on the sieve, the precipitate is carried on to a sailcloth filter. On the metal sieve will be found scraps of tin-plate not affected by the acids, and some tin solder; the former is thrown into the boiling vat, the latter cast into ingots for sale. The precipitate is washed in the filter as long as any trace of iron remains, and is then placed in canvas sacks, and the water squeezed out by means of a screw or hydraulic press. The precipitate is employed in making chloride of tin; it is well to dissolve it in hydrochloric acid as soon as it is taken out of the press, or, at any rate, to sprinkle it with it, as otherwise the tin oxidises rapidly, and the oxide will not afterwards dissolve in the acid. It is far more advantageous to convert the precipitate into chloride than to cast it in metallic ingots, as the former, being very finely divided, is worth much more in the market. The mode of making crystallised chloride of tin is too well known to require description. The treatment of the residues insoluble in hydrochloric acid is important. These residues consist principally of chloride of lead and oxide of tin. These have been successfully treated in a small Belgian zinc oven, in which the residue is made of a red heat in six retorts, arranged in two lines, and inclining forwards at a considerable angle, after being mixed with twice its own weight of fine poor coal. If the residue contain sufficient chloride of lead, all the tin will be transformed into volatile chloride, which condenses in the retort, and metallic lead is also formed, partly in the neck of the retort, and partly mixed with the residue at the bottom, from which it is separated by washing. If there is not sufficient chloride of lead in the residue, some must be added from the receptacle, described in paragraph 2.

'4. When only a small quantity of tin scrap is treated daily, and sulphuric acid can be obtained cheap, it may be advantageous to convert the iron from which the tin has been recovered into sulphate, but not when large quantities are dealt with. At Liège about four tons of tin scrap have been treated daily, which would give about twenty tons of sulphate of iron. Such a quantity could not be placed advantageously in Belgium. It was necessary, therefore, either to find other applications or remove the prejudice against such scrap iron. This scrap, made up into compressed packets, yields, with a loss of 20 to 25 per cent., an extremely brittle iron, but which may be rolled hot, and then presents an excellent surface.'

Disaggregation of Tin.—It has been observed that organ pipes after long use, become brittle and fall to pieces. OUDEMANS (*Chem. Jahresb.*, 1872) states that plates of tin, during conveyance from Rotterdam to Moscow in severe cold, were broken into small fragments, resembling sulphide of molybdenum.

A similar phenomenon has been observed at the Royal Pyrotechnic Laboratory at Spandau: 295 kilograms of tin plate acquired lamellar exfoliation, in which it crumpled into minute particles. Similarly, 1,950 kilograms of blocks of tin suffered. According to Dr. PETRI, the tin could be more easily powdered than filings of unaltered tin, and evolved hydrogen more quickly with acid.

From these observations it appears probable that in this disaggregation the repeated little shocks, combined with variations of temperature, essentially co-operated.—POGGENDORFF's *Annalen*, 1877; *Philosophical Magazine*, December 1877.

Tin Boxes for Biscuits.—The increased manufacture of biscuits has led to a large demand for tin boxes wherein to pack them for transport. The edges of these boxes were formerly soldered together in the same way that those of other tin goods are. A step in advance was made a few years since by Mr. JAMES JAMES in some tin box-

making machinery which he designed and made for Messrs. Huntley and Palmer, of Reading. There the boxes were shaped and the sides jointed up in the same machine, but the bottoms had to be soldered in. Recently, however, Mr. James has devised a plan whereby the use of solder is entirely dispensed with, the bottoms being fixed in by machinery. The machine now used measures about 14 feet long by 6 feet wide, and stands about 6 feet high. At one end is a table on to which the plates of tin are fed, they having first been trimmed square, and pierced at certain points along their edges. From the feeding-table each plate is drawn into a hopper, from which it is conducted under a presser plate, where it is acted upon by rollers, and gets one of its edges turned up in the form of a hook. It is then moved forward another stage under a hopper containing a number of copper-coated wires. The hooked edge of the tin plate releases one of these wires, which it takes with it, and at the next point the wire is pressed into the groove of the plate by a cam action. A presser plate then holds the sheet of tin down while another roller acts upon the hooked edge, curling it entirely around the wire. This forms the top edge of the box. The plate is then mechanically moved on another stage, where one of the sides of the box is folded up, and the edge of the tin at the opposite end of the sheet is turned up to form the joint. It is then moved along to the next stage, where a mandril passes over it, and where the plate is further bent or angled round the mandril by means of steel jaws. The two ends of the tin plate are then brought together, folded into a seam, and pressed by means of a lever, at the end of which is a hollow-headed hammer. The mandril is then withdrawn, and the box without a bottom is then thrown out of the machine to the side, where it is received by an attendant. It is then transferred to another machine, where the bottom is mechanically affixed, the lids also being made in a somewhat similar manner. The apparatus is exceedingly precise in its action, and works very smoothly and quietly, turning out boxes at the rate of eight per minute in ordinary work. It is attended by three boys, one of whom feeds the tin plates on to the table, the second feeds the framing wires into the hopper, and the third receives the boxes as they are turned out of the machine. The apparatus is automatic, all the varied processes following each other consecutively, but rapidly, each box only taking 7½ seconds to make.

TITANIUM. This metal is often prepared by the ignition of metallic potassium or sodium, with the double fluoride of titanium and potassium (TiK^2F^6). The titanium thus obtained is in the form of a grey powder, which decomposes water very readily at 100°; but it has been proved that titanium thus obtained always contains some unoxidised potassium or sodium.

The following method is recommended:—Through a tube with a bulb in the middle of it, in which sodium is melted, vapours of the tetrachloride of titanium are passed. By the following reaction titanium is obtained:—

$$TiCl^4 + Na = Ti^4 + 4NaCl.$$

The mixture of titanium and chloride of sodium is washed with cold water. The remaining precipitate of titanium is washed with ethyl-ether, and dried over sulphuric acid.

Titanium carefully prepared by this process has no action on water at 100, and only decomposes it at about 5,000.—Sergius Kern, *St. Petersburg Chemical News*, vol. xxii. p. 57.

TOAD-FLAX. The *Linaria cymbalaria*, common name *Mother of Thousands*.—See Antirrhinum.

TOBACCO-PIPE MAKING MACHINE. The ordinary methods adopted for manufacturing and baking tobacco pipes were described in vol. iii. p. 1020 of the last edition.

Mr. Robert Rankin has invented a highly ingenious tobacco-pipe making machine, which, from its powers of production, and its simplicity of action, is destined to fill an important place in the future of this trade.

By the aid of the accompanying engraving (*fig.* 2555), the principles of this machine will be rendered clear.

Secured to the top of supporting columns, A″, is a bed plate, A′, in which are V-shaped grooves, in which moves intermittently a revolving table, A, carrying a series of moulds, *a a*. Motion is given to this table by means of a driving wheel, with belt and pulleys.

Two pairs of mitre wheels, 2′ 2″ and 3′ 3″, give motion to two second motion shafts, 2 and 3, at the same speed, and these shafts in turn each reciprocate the parts it has to move, and the intermittent motion is given to the annular revolving table, A, by means of an improved screw or cam barrel, 4, having a plain semicircular feather, 6′, round its centre, which works for rather more than half a revolution into corresponding holding notches, 5′, slotted or formed in a horizontal rim, near the upper outer edge of

the table, A, so as to hold it steady during that half of the revolution of the barrel 4. While the feather, 5, is out of one holding notch, 5′, a semicircular screw feather, 4″, formed round half of the barrel opposite to and diagonally across the plain vertical feather, 5, comes round and takes on to an anti-friction conical pulley, 5‴, so as to turn the table, A, to the extent of one of its divisions or notches, and keep it there until the advance end of the holding segment, or feather, 5, enters the new notch brought round opposite to it. The position of the barrel, 4, its holding feathers, 5, 5″, and the mould boxes, *a*, *a*, are so arranged that when the screw feather, 5″, is turning the table, A, during one half of the revolution of the barrel, the two halves of each mould box, *a*, are closed as it reaches the side next, and at right angles to the shaft, 3, by short wipers, *f f*, raising the hinged plates, *b*, and acting on the curved wedge or tilting surfaces, *g*, on the back of the plates, or on the halves of the moulds, *a a*, so as to close the plates, and the two halves of each mould box with great power as it is brought round with the turning table, A, over a stationary cam, by the anti-friction roller on the lower end of the lever, *d*, acting on the angled surface of the fixed cam, thus com-

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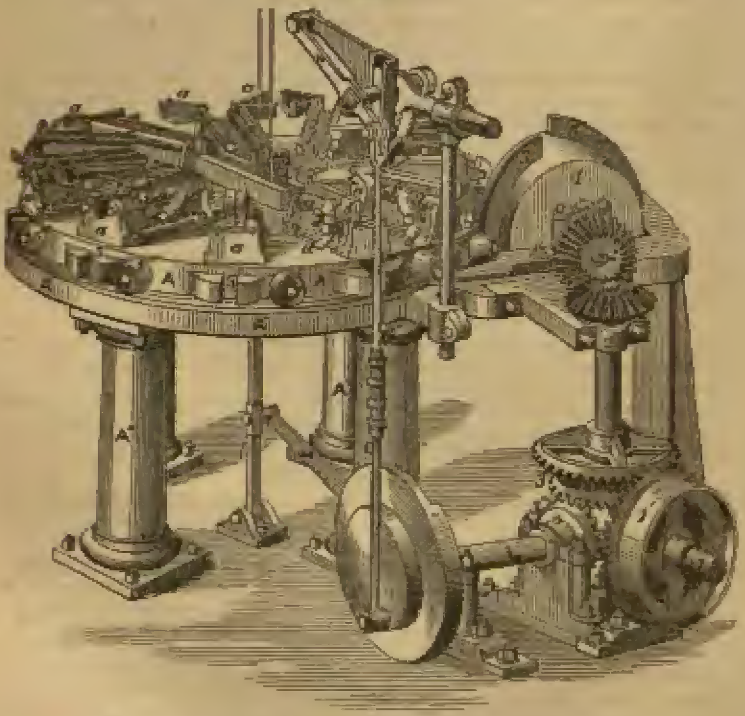


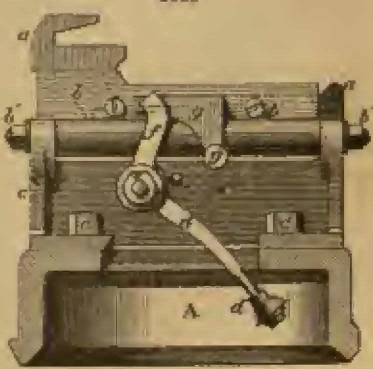
pressing and forming the blank of clay into a properly shaped pipe, with the bowl or mouth upwards below the stapper, *o*, which, as the table comes to rest, is brought down to form the bowl of the pipe by the rod, *o*, actuated by the crank disc, *m*′, actuating the level, *n*, of the stapper. As each new mould, *a*, with the clay compressed in it, is brought round by the table, A, under the stapper, *o*, the stem part, *a*′, of the mould is left in exactly a radial line, with a reciprocating and revolving drill, *i*, actuated by a cam formed on the back of the disc, *m*′, through the reciprocating rod, *m*, and lever *l*, so as to drill the hole in the stem of the pipe simultaneously with the forming of the bowl by the stappers. The next intermittent movement of the table, A, brings the mould box, *a*, over an opening cam, and the anti-friction roller of the lever, *d*, coming in contact with the bevelled surface on the opposite side to that of the closing cam, reverses the lever, *d*, and its oscillating spindle, *e*, and turns down the arms, *f*, of the levers, *d*, which come in contract with the projecting pins, *g*′, on the gripping and tilting segments, *g*, so as to tilt and bring down the two plates, *b*, and

halves of the mould, *a*, whilst the table is travelling past the tilting cam, leaving the finished pipe ready for removal from the opened halves of the mould, *a*, which may then during the same pause be oiled and cleaned, if necessary, previous to placing in a fresh block of clay in readiness for being brought round by the table, A, for the sequential repetition of the several operations already mentioned.

If these pieces of clay are to be operated upon in progressive rotation, the first motion of the table closes and compresses the mould, *a*, and places it under the stopper, *o*, and opposite the wire drill, *i*; the second step cuts off the superfluous clay from the bowl of the pipe, and the third step opens the mould for the finished pipe to be removed. In the engraving the revolving table is shown as working with eleven moulds. Under a new arrangement each alternate half-revolution of the driving cam barrel closes one mould, hits the superfluous clay off another, and opens a third; the other half-revolution of the cam barrel is so adjusted as to keep the revolving table stationary during the time the stopper, *o*, and the wire drill come into action. Thus it will be observed that three operations take place simultaneously while the table is in motion, and two while it is at rest, and while one attendant is taking out a finished pipe and another is placing a fresh roller of clay in the mould. To increase the speed of production the revolving table may be formed sufficiently large in circumference to enable double sets of moulds to be operated upon, with attendants at opposite sides.

Fig. 2556 is a sectional elevation of a part of the machine, detached to show the details and action more clearly, the mould, *a*, being shown in side elevations in its closed position, with the pipe formed therein, as seen in dotted lines. The cam segments operate the lever, *d*, by the anti-friction roller, *d'*, on its lower pendent end, for opening and closing the moulds, *a a*; and *b b* are the swivelling plates to which the two halves of the mould are screwed, and which turn on the two axes, *b'*, in the carrying frame, *c c'*, secured to the turning table, A.

2556



It appears that the weekly output of tobacco pipes by the system of hand labour is about 40 gross per man, but it is stated that with RANKIN's single machine thirty pipes per minute can be produced, which give a production weekly of 480 gross.

The machine requires driving power, but we are informed that about 20*s.* per week will cover the cost of driving four such machines as the one we have described, and only two boys are required to attend to the working of the machine itself, and very little training is necessary.

The machine itself costs about 100*l.* It is made by Messrs. STEVEN and STRUTHERS, brass founders, Elliot Street, Glasgow.

The cost of pipe making by hand is 7½*d.* per gross, or 11*l.* for 480 gross, whereas the making of 480 gross of pipes by the machine costs but 2*l.*

TOBACCO. Our tobacco imports were in 1875 and 1876 as follows:—

On March 27, 1863, it was settled that *unmanufactured* tobacco containing 10 lb. or more of moisture in every 100 lb. should be chargeable with 3*s.* 1$\frac{6}{10}$*d.* per lb.; containing less than 10 lb. of moisture in every 100 lb., 3*s.* 6*d.* per lb.

Manufactured tobacco containing more than 13 lb. of moisture in every 100 lb. is chargeable with 3*s.* 9*d.* per lb.; not containing more than 13 lb. of moisture in every 100 lb., 4*s.* 6*d.* per lb.

Cigars are charged with 5*s.* per lb. duty; tobacco of foreign manufacture, 4*s.* 6*d.* per lb.; manufactured in bond, 4*s.* per lb.; other sorts, including cigarettes, 4*s.* per lb.

1875.

	Lb.	£
Unmanufactured	48,043,559	1,750,967
Manufactured snuff	6,397	132
Cigars	1,563,902	1,080,211
Cavendish or Negrohead	1,681,595	86,634
„ „ manufactured in bond .	43,400	8,662
Other sorts	70,710	15,603

1876.

	Lb.	£
Unmanufactured	76,814,974	2,675,890
Manufactured	3,024	204
Cigars	1,680,502	1,195,082
Cavendish or Negrohead	2,065,963	104,896
" " manufactured in bond	42,002	8,400
Other sorts	69,103	14,730

In 1877 we imported 75,040,731 lb. unmanufactured tobacco, of the value of 2,664,100*l*., and 3,792,390 lb. of manufactured tobacco, of the value of 974,315*l*.

TONITE. (See EXPLOSIVE COMPOUNDS, p. 355.) The following has been received from the works at Faversham in answer to an inquiry respecting the name:—

'The word tonite is a misnomer altogether, and ought never to be used, the proper title of the explosive being 'cotton powder,' and which is also the original term, and has never been discontinued.

'Cotton powder consists of the purest gun cotton crushed to an impalpable dust and incorporated with an equal weight of the nitrate of baryta, which has been selected on account of its richness in oxygen and its general inertness as against blows and friction. The whole of the processes are carried out in a wet state and with perfect security to the workpeople; finally the powder is moulded by powerful machinery, at a pressure of five or more tons on the square inch, into solid cartridges of diameters and weights suitable for the work to be done in blasting.

'The chief points in the value of this explosive are its very great power and its stability. The cartridges, when set free, burn with a brilliant greenish flame, which may be seen for miles, and is very serviceable for signal purposes.

TOPAZ. New South Wales.—Some very large crystals have been met with; a portion of a large bluish green-coloured crystal found at Mudgee, and now in the Melbourne Technological Museum, weighs several pounds; and others weighing several ounces are by no means rare; they are sometimes 2 to 3 inches long and broad in proportion, especially those from Uralla. The pale bluish-green tint is the most common colour; sometimes they are slightly yellow.

It is comparatively abundant all over the granite region of New England. It occurs associated with tinstone in veins traversing the eurite and greisen granites near Elsmore and other parts. Some of the small crystals found with the tin ore are beautifully developed.

Found also at Bingera, Two-mile Flat, Bathurst; Bell River, also Macquarie, Abercrombie, Shoalhaven, and Lachlan Rivers.—LIVERSIDGE, *Minerals of New South Wales.*

TOPAZOLITE. From Mill Rock, in the trap rocks of Newhaven, Conn., U.S. This mineral (specific gravity 3·03) has been analysed by G. HAWES:—

Silica	51·78
Alumina	14·20
Ferric oxide	3·59
Ferrous oxide	8·25
Manganous oxide	0·44
Lime	10·70
Magnesia	7·63
Soda	2·14
Potash	0·30
Phosphoric anhydride	0·14
Ignition	0·63
	99·89

TORPEDOES. There are several kinds of torpedoes; the three principal systems may be briefly described as follows:—

In the WHITEHEAD system the torpedoes are carried by vessels constructed for the purpose, and are made so as to maintain a fixed direction under water. There is a horizontal tube fixed in the keel of the torpedo vessel in a line with the bow about eight feet under water. The torpedo is worked by compressed air and travels at a rate of six or seven knots an hour at first, but the speed gradually decreases owing to the diminution of the expansive force of the compressed air as the torpedo proceeds. As soon as the torpedo is launched from its tube the speed of the vessel must be re-

duced, so that it may be at least a knot or a knot and a half behind when the explosion takes place.

In another system the torpedoes are fixed to spars projecting from the bow of the ship; but the success of this plan generally depends on the attacking ship being able to take the enemy by surprise. This system has been much used by the Americans, who employed very small vessels presenting little surface above the water, or even occasionally submarine boats, for the purpose of concealing their movements as much as possible from their adversary. This system cannot be applied to large ships, on account of the difficulty of using electricity for exploding the torpedoes, and the danger of employing self-acting exploders in the confusion of a sea-fight.

Captain HARVEY's system consists in towing two torpedoes at a lateral distance of about fifty yards from the ship's track. They are towed along the surface of the water till close to the ship to be attacked, when the towing line is loosened, the torpedo dipped under the ship, and as soon as it touches the explosion takes place. One advantage of this system over the other two is that the torpedoes may be towed by almost any ship, and thus become a defensive weapon against the attacks of a ram.

TOUCHSTONE. The following analysis is given in *Les Mondes* for December 1875:—

Silica	84·40
Alumina	6·25
Oxide of iron	1·16
Lime	0·43
Magnesia	0·13
Potash	0·69
Soda	1·70
Lithia	traces
Phosphoric acid	0·05
Sulphur	0·60
Water	0·70
Organic matter	1·35
Loss	·25

TOUGHENED GLASS. See GLASS, TOUGHENED.

TRASS, ANDERNACH. 'The tuffstone from which Andernach trass is ground is a volcanic product of the Eastern Eifel range, on the left bank of the Rhine. The principal quarries are in or near the valley of the Brohl, and in the valley of the Nette, close to Andernach. The tuffstone consists of the ash ejected by the volcanoes of prehistoric times, compressed by thick layers of superincumbent pumice-stone subsequently deposited, and it only crops out at or near the surface at the point above mentioned. In the Nettethal the superincumbent layer of pumice-stone is more than 39 feet (12 mètres) thick. In the Krüfferthal it is only 3¼ to 6½ feet (1 to 2 mètres) thick. The tuffstone, however, which is most easily obtained is that of the Brohlthal and its neighbouring valleys, where the layer is from 65½ to 98 feet thick (20 to 30 mètres).

'German trass is frequently and largely adulterated with wild pumice or other stone. In the Brohlthal the temptation to adulterate is great, for not only is the wild and bad tuffstone close at hand, but it must be removed before the good layers can be reached. Pumice-stone is found also in large quantities in different parts of the Neuwied basin and close to the tuffstone quarries.

'Good trass may be known by the following characteristics:—When thrown in a heap, the slopes should run down readily. On being formed into a ball in the hand, unadulterated trass falls immediately into small pieces, and the pieces themselves separate; whilst with old, wild, or damp trass the ball falls into powder at once. Good dry trass should be strongly hygroscopic, a quality which is ascertained by exposing it for half a day on damp stones. The weight also in a given quantity of dry trass is greater than that of damp trass, owing to the volume of the latter increasing at a greater rate than the weight. Thrown into a glass of water and stirred, good trass sinks quickly, the water soon becomes clear, and only a few particles of pumice-stone remain floating. The transition from the fine to the coarse particles in such a precipitate is much more regular in the case of good trass than in that of bad or wild trass. With wild trass especially, the coarser particles are covered with a yellowish slimy coating resembling mud. When adulterated with sand, a considerable quantity of it forms the bottom layer of the precipitate.

'The needle-test is that usually adopted, and is prescribed in Holland for Government works. The diameter of the needle is ·047 in. (1·2 millimètres), and a mortar

consisting of two parts by measure of rich slaked shell or limestone, and one part of trass mixed with water to the consistence of putty, must, after three or four days, support such a needle when loaded with 10½ ozs. (3 hectograms).

'A simple chemical examination will also aid in ascertaining the value of the trass, and in detecting adulteration. Ground trass has a composition of alumina, silica, lime, and oxide of iron, of which 50 to 60 per cent. is silica, and only about 5 to 10 per cent. lime. The silica, which is present in a soluble or gelatinous form, when mixed with lime and water, forms a silicate of great hardness, capable of strong adhesive power, and of resisting the action of air and water. This characteristic of the gelatinous silica gives to the trass its setting properties, and the more of this silica there is in the trass the greater is its value.

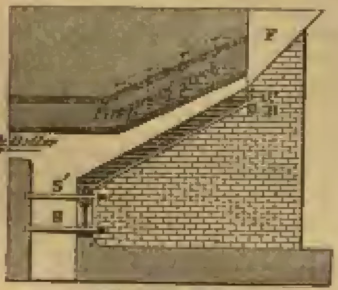
'Since lime is already present in the tuffstone, it is clear that in damp trass the conversion of the soluble silica will have partly taken place. Damp trass is therefore objectionable, and as the trass itself is strongly hygroscopic, old trass is also capable, by the absorption of water from the air, of becoming set in its own constituents. This is one of the reasons why much of the tuffstone which comes from the Nettethal is of inferior quality. The quarries in that valley are much burdened with water, which renders the tuffstone damp.

'Trass from tuffstone procured from old buildings is equally bad, even if the stones have not been set in mortar. If they have been so built, they will naturally have lost much more of their soluble silica by combination with the lime in the mortar, both during the building and afterwards by the action of rain, &c. The chemical examination has for its object to ascertain the presence and quantity of the gelatinous silica.

'Adulteration with wild trass may also be detected by the microscope, which will clearly show small pieces of quartz enclosed in the wild stone; whilst in the genuine trass the shining black colour of the obsidian, which is present in large quantities, may be recognised.'—*Steenpoot; Abstract Papers, Civil Engineers' Institute.*

THE 'TREPPEN ROST.' (See FURNACE, STEP, p. 397.) The brown coal occurs in such abundance in Bohemia, Germany, and Westphalia, that it is commonly

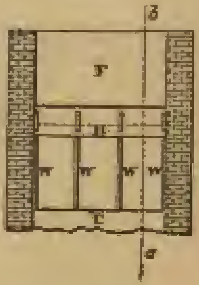
2557



LONGITUDINAL SECTION
According to a = b

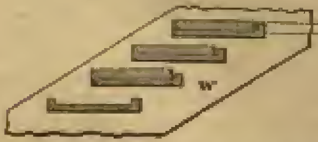
0 1 2 3 4 5 FEET.

2558

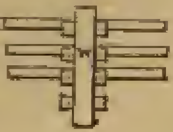


PART PLAN
Showing Checks W.

2559



2560



CHECKS W. WITH STEPS

0 1 2 3 4 5 6 7 8 9 10 11 12 FEET

used for steam engines, and to enhance its heating effect it has been found necessary to reconstruct the fireplaces for the boilers. Several inventions have been made, but

the improvement worthiest of notice is the so-called 'treppen rost,' or step furnace. *Fig.* 2557 is a drawing of a fireplace of this kind, and the construction and mode of working is as follows:—

'Above an opening of 45 centimètres in width, communicating with the ashpit, lies a slide frame, s, with massive slides of 10 to 12 millimètres in thickness, the whole resting in front, for the sake of solidity, upon a cast-iron plate, *a*, 13 centimètres broad, and 4 to 5 centimètres thick. Upon the slide frame, s, is placed a cast-iron double T support, 24 centimètres in height, 13 centimètres broad, and 12 millimètres thick, and upon this lies a second slide frame, s'. The slide of this frame being 26 millimètres thick, are, however, perforated or broken longitudinally, in order to form a grating; or better, movable fire-bars 6 to 7 centimètres thick are used instead of the broken slides, which are liable to crack. Upon the slide frame, s', lies a second cast-iron plate, *c*, of the same dimensions as *a*, and at a suitable height a third cast-iron bar, n, 9 centimètres high and 6 centimètres broad, is fixed into the side walls of the furnace. The length it is let into the walls is above 15 centimètres, whilst *a* and *c*, and the slide frames, s and s', enter the walls only about 8 centimètres with their ends. Upon what may be called the cross supports, n and *c*, rest now, with their ends, the cast-iron cheeks, w, in such a manner that they may be freely shifted broadways, and carry step-like (hence the name of the furnace) the several fire-bars, of which the upper one, *p*, is about three times broader than the rest. Above *p* is fixed the cast-iron supply-funnel, *r*, serving for the receipt of the fuel, and which is sometimes furnished with a slide for regulating the supply of fuel into the furnace. The fireplace is fixed between two stone walls, and covered by a fire-proof arch, which is either inclined or smooth, or, as indicated by the dotted lines, broken step-like for the purpose of offering to the combustible gases more heated surface on which they strike, and are set burning. The cheeks, w, are 25 millimètres thick, and 10 to 12 centimètres broad, and placed at 0·4 to 0·6 mètre distance from each other. The whole length of the furnace is generally 2 mètres or smaller, the breadth equal to or less than 1·3 mètre; and the inclination of the cheek, w, is most advantageously at an angle of 30° (*i.e.* for the burning of brown coal, for which these furnaces are most suitable, and nearly exclusively used).

'The most approved connection of the fire-bars with the cheeks, w, is shown in *figs.* 2559 and 2560. Their thickness is 1 to 12 millimètres, the vertical distance between the two bars 19 to 20 millimètres, the distance between their surfaces 27 to 32 millimètres, their breadth 118 to 120 millimètres, and they project one over the other about 47 millimètres. The working of such a furnace requires much less strength and intelligence than that of a common plane fireplace. The funnel, r, is filled with the fuel, and according as the latter burns off the steps (which is easily seen), the fireman pushes a fresh lot from top downwards by means of a spade-like tool, introduced between the lower edge of the funnel, r, and the top bar, *p*. The gradually accumulating ashes are from time to time removed from the fire-bars by means of a flat piece of iron, which is moved hither and thither over the latter. In order to remove cinders and ashes from the upper slide, s' (s being always kept a little open to let draught in for perfect combustion), the slide, s, is first shut, then s' opened to let the ashes and cinders drop upon s; then s' is shut again, and fuel stoked down to cover it, and now, finally, s is opened, so that the ashes, &c., can fall down into the ashpit. In this manner the detrimental introduction of a large amount of cold air into the furnace is entirely avoided. The chief advantage of this furnace consists in the steady, nearly continuous, burning of fuel, and that with proper regulation of the draught the combustion can be rendered close upon perfect, whilst all smoke is consumed. To this has to be added another great advantage, namely, that during the supply of fuel no unnecessary amount of cold air is introduced into the furnace, and that, as previously mentioned, a common workman is able to serve the latter easily and well, and without being exposed to any strong heat bursting into his face. The furnace has also, however, some drawbacks, viz., that no coal can be burned in it that bakes or clogs, and that the fuel rests upon a larger area of iron, being, therefore, much more cooled, and for a larger surface extent prevented from burning, than in the common plane furnace.'

It should be explained that this more comprehensive description of the STEP FURNACE has been obtained since the short notice given on p. 397 was printed. It has been thought desirable, for convenience, to reprint the woodcuts given on that page in connection with this description of the furnace.

TRIOLITE. The name given by Professor J. LAWRENCE SMITH to a peculiar mineral found in meteorites, which he identified as protosulphide of iron, and which is not found in any mineral of telluric origin. In some Mexican minerals he has found it associated with a sulphide of chromium, which Professor SMITH believes to be of celestial origin.

TRIPHENYLATED ROSANILINE BLUE. See ANILINE, ELECTROLYSIS OF.

TRIPOLI, ARTIFICIAL. Dr. PHIPSON has analysed some samples of imitations of tripoli found in commerce, and he finds them to be composed as follows:—

Silica	1·0	84·7
$CaOCO^2$	88·4	6·1
Fe^2O^3, &c.	5·6	4·8
Water	5·0	4·4
	100·0	100·0

TRIPOLITE. (TRIPOLI, vol. iii. p. 1025.) In the island of Barbadoes a deposit of tripolite exists mixed with carbonate of lime.

Dr. T. L. PHIPSON (*Chemical News*, September 8, 1876) gives the composition of the Barbadoes, and also a comparative analysis of a Swedish sample:—

	Barbadoes	Dingelfors, Sweden
Silica	71·50	78·00
Oxide of iron and alumina	2·52	0·15
Carbonate of lime	10·60	
Phosphoric acid	0·08	
Combined water and a minute quantity of organic matter	9·84	15·85
Moisture	5·66	
	100·00	100·00

Under the microscope the Barbadoes tripoli is seen to be exceedingly rich in the remains of fossil infusoria, the forms being similar to those observed by EHRENBERG (see vol. iii. p. 1025). The silica in it is hydrated, and it is soluble to a great extent in solution of potash.

Dr. PHIPSON says:—'The genera most easily recognised in these deposits with the aid of a moderately-powerful microscope (200 to 250 diameters) are *Desmidium*, Euastrum, Xantidium, *Peridinium*, Gomphonema, Hemanthidium, *Pinnularia*, *Navicula*, *Actinocyclus*, *Pixidula*, Gallionella, Synedra, and *Bacillaria*. I have italicised those which appear to be most prominent in the Barbadoes deposit. Of these Gallionella, Desmidium, Bacillaria, and Navicula are supposed to be plants, all the others to be animals. The great resemblance of these fossil animalcules to some of the active little beings in our ditches and stagnant waters is very striking.'

This authority states that genuine tripolite from the Puy-de-Dôme (France) gave FOURNIER—

Silica	87·2
Water	10·0
Alumina, Oxide of iron, &c.	2·8

And a sample from Algiers gave SALVÉTAT—

Silica	80·0
Water	9·0
Oxide of iron, Alumina, Lime, &c.	10·0

The silica being most soluble in strong boiling alkaline lye.

The Barbadoes tripolite is found to be a bad conductor of heat, and has been used with advantage for covering boilers.

BOETTGER says that tripolite will displace the aniline colours from their solution in spirit and fix them, so that after a while the solution filters colourless.

TRITON VARIEGATUM. See CONCH.

TUNGSTEN. M. F. JEAN heats wolfram, reduced to an impalpable powder and intimately mixed with 3 per cent. carbonate of lime and 20 to 30 per cent. of chloride of sodium, to a low redness for half an hour in a crucible or in a reverberatory furnace. When the mixture is cold, it is powdered and boiled for a quarter of an hour with hydrochloric acid, which dissolves lime, ferric and manganic oxides, and leaves undissolved all the tungstic acid in the state of a crystalline powder of a fine lemon colour, which is purified by repeated washings in acid, and is then converted into tungsten by reduction with hydrogen at a red heat.

M. F. Jean considers wolfram to be a tungstate of the protoxides of iron and manganese.

In vol. iii. p. 1039 one process for preparing tungsten from the tungstate of soda, and another from tungstic acid, will be found. M. F. Jean communicates the following process to the *Académie des Sciences de Paris*: The wolfram is reduced to an impalpable powder, mixed with 3 per cent. of carbonate of lime and from 20 to 30 per cent. of chloride of sodium, and heated for half an hour to dull redness in a reverberatory furnace. When the mixture is cold it is powdered, and then boiled for a quarter of an hour with hydrochloric acid, which dissolves the lime and the oxides of iron and manganese, with disengagement of chlorine, leaving the whole of the tungstic acid in an insoluble state as a crystalline lemon-yellow powder. This is finally reduced at a bright red heat by hydrogen. With pure carbonate of lime, and without adding the chloride of sodium, it was found impossible to completely decompose the wolfram; but with about 20 per cent. of pure lime decomposition was easily effected at a dull red heat.—*Comptes Rendus*, July 12, 1875.

TURKEY RED, *with Artificial Alizarin.* In M. Reimann's *Färber Zeitung*, Dr. P. Romen states that cotton wool, to be dyed with artificial alizarin, is oiled in the ordinary manner used in employing madder or garancin, although sometimes one oil bath may be dispensed with. The treatment with tannin is suppressed, and the oiled yarns are passed into an alum mordant, which should be rendered as neutral as possible. To 50 kilos. of crystalline alum add 15 kilos. of soda crystals, mix the solution, stirring well, and set the clear liquid at 5° B.

The cotton steeps for a day in this liquid, and is then carefully washed and wrung out. The dye-beck consists of alizarin and tannin, ½ kilo. of the latter per 50 kilos. of yarn. If the water is not calcareous 100 grams of chalk must be added. The dyeing is carried on very slowly and gradually, beginning with a perfectly cold beck, which is raised to a boil in two hours, and kept slowly boiling for another hour. The yarn is not then cleared, but raised at once with curd soap and annatto. For rose shades the yarns must be treated with tin crystals.

TYPE, *Composing and Distributing.* See Printing.

TYPE WRITER. The name of a machine manufactured by Messrs. Remington and Co.

The type writer more nearly resembles in outward appearance a sewing machine than anything else, being a piece of mechanism about 16 inches in length, the same in width, and the same in height, measuring from the little table on which it is fixed. On the top of the apparatus is an indiarubber-coated roller termed the paper cylinder, which is 8½ inches long and 2½ inches in diameter, and at the side of which and parallel with it is a small wooden roller. Between these two rollers the top edge of a sheet of paper is inserted, and the cylinder slightly revolved, so that the paper is brought into the proper position to receive the first line of 'writing,' as it is termed. Immediately under the paper cylinder, and in line with its axis, is the ink riband, which is 12 yards in length and 1⅜ inch in width. At starting the riband is wound on to a drum on one side of the machine, from which it is slowly drawn off as the operation of writing progresses, and by the aid of a spring is wound on to a corresponding drum on the other side of the machine, a portion of the riband of the length of the paper cylinder only being exposed at one time. Beneath the ink riband is a circular opening 7 inches in diameter in the case containing the mechanism, and it is at a point precisely in the centre of this opening that every letter, figure, or character is made to appear in succession to perform the operation of writing. See Allsopp's *Mechanical Printer*, described under Printing, p. 692.

U

ULTRAMARINE. (Vol. iii. p. 105.) There are three methods of preparing ultramarine generally followed; they result in—

α. Sulphate ultramarine.
β. Soda ultramarine.
γ. Silica ultramarine.

α. The preparation of sulphate ultramarine is included in two stages:—

1. Preparation of green ultramarine.
2. Conversion into blue ultramarine.

1. The kaolin, sulphate of soda, and charcoal are all finely pulverised; or if solutions of sulphate of soda, soda, and sulphide of sodium are used instead of powders, the kaolin is stirred with the solution, and the mixture evaporated to dryness and ignited. The materials are employed in such quantity that the soda shall saturate half the silica of the kaolin, and shall be present in sufficient quantity to form with the sulphur polysulphuret of sodium. This and the formation of another sulphuret (Na^2S) are obtained by observing the following proportions:—

Dry kaolin	100	100
Calcined GLAUBER'S salt	41	83–100
Calcined soda	41	—
Charcoal or pitcoal	17	17
Sulphur	13	—

This mixture is to be ignited without access to air, and a white mass is obtained, which becomes green by exposure to air, and blue by being calcined in contact with air. The mixture is placed in fire-clay crucibles and well rammed down the crucibles, being maintained at a high temperature, with a limited supply of air for eight to ten hours, the ignition being completed at a white heat. The crucibles when cooled are found to contain a semi-fused grey or yellow-green mass, which is repeatedly lixiviated with water. The green ultramarine contains, according to STOLZELL'S analysis (1855) in 100 parts—

Alumina	30·11
Iron	0·49
Calcium	0·45
Sodium	19·09
Silica	37·46
Sulphuric acid	0·70
Sulphur	6·08
Chlorine	0·37
Magnesia, potash, phosphoric acid	traces
Oxygen	5·19
	100·00

2. The conversion of green into blue ultramarine is effected by roasting the green ultramarine and sulphur at a low temperature, with access of air. Sulphurous acid is formed, a portion of the sodium oxidised into soluble sulphate being washed out; the sulphur originally present in the green ultramarine remains combined with a smaller quantity of sodium. The roasting is generally effected in an iron cylinder, somewhat similar to a gas retort, sulphur being added until the required depth of blue is obtained. The ultramarine is then pulverised, lixiviated, dried, and assorted as to quality.

β. Soda ultramarine is prepared from the following proportions of materials:—

Kaolin	100	100
Sulphate of soda	—	—
Soda	90	100
Carbon	6	12
Sulphur	100	60
Resin	6	—

The ignition is effected in the manner previously described. By increasing the proportion of soda and of sulphur, blue ultramarine may be formed at one operation.

γ. Silica ultramarine is prepared in a similar manner, silica being added to the former materials to the amount of 5 to 10 per cent. of the kaolin. Blue ultramarine is the immediate product of the calcination. The process, however, is difficult to manage, on account of the tendency to fusion amongst the materials employed.

When green ultramarine is heated to 160° C. in water in sealed tubes, it assumes a fine bright blue colour. The weight, however, remains nearly the same (the water taking up only a small quantity of sodium compounds), and its composition is unaltered. J. PHILIPP found that sulphur exists in the same condition in blue ultramarine prepared in the wet way as in the green ultramarine from which it was obtained. The formation of blue ultramarine is, therefore, in no way dependent upon the oxide of sulphur, as has been thought. J. PHILIPP concludes that the difference between the two ultramarines is due to the presence in the green substance of a small quantity of sulphide of sodium, either mechanically mixed or chemically combined with it, on the removal of which the blue colour appears. He

found that green ultramarine is actually formed by fusing blue ultramarine with sulphate of soda and charcoal.—*Deut. Chem. Ges. Ber.* ix. p. 1169.

UMBRELLA RUNNER. An umbrella being fitted with the runner represented (*figs.* 2561, 2562), which has been patented by Dr. HIGGINS, of New York, and is introduced by Messrs. SANGSTER, it is only necessary to push the runner to raise the ribs or to pull it for the purpose of lowering the umbrella.

2561

2562

The construction of runner is as follows:—The inner tube, A, has fixed to its upper end the stretchers, s, as in ordinary cases, and is substantially like the runner usually used, except that it is longer, and has cut through it a slot, a, intended to receive the spring, c, fitted in the stick, c, and which keeps the umbrella close or expanded. Over the tube, A, is an outer tube, P, which is somewhat shorter than A, and slides up and down upon it, and is swelled or expanded at or about its middle, as shown, sufficiently to allow the spring, c, to be fully expanded, or thrown out when such swelled part is over either of the springs, at which time the outer tube also entirely conceals the spring. The action is as follows:—When the umbrella is shut, and it is desired to open or raise it, it is not necessary to press with the thumb or finger the spring, c, down through the slot, a, and into the spring recess in the stick, as has to be done in ordinary umbrellas to allow the runner tube to be pushed up, but the outer tube, P, is moved upward and upon the tube, A, until its upper end comes in contact with the stretcher rim, s'. The first upward movement of the outer tube, P, brings the inclined surface or face, b, of its swelled portion against the spring, c, and presses the spring into the stick, so that the tube, A, can pass over it as if the spring was forced in by the thumb or finger, and then the further upward movement of the outer tube carries the inner slotted tube along with it over the spring, and thus raises or opens the umbrella, as in ordinary cases. A continued movement in the same direction of the two tubes of the runner in the manner described thus performs the two offices of first pressing in the holding spring, and then carrying up the inner tube, which expands the umbrella. When the umbrella is fully expanded the slot, a', in the tube, A, is brought over the upper spring of the stick, and the spring passes into the slot and holds the umbrella open. When it is desired to close the umbrella a similar movement of the runner tubes takes place, but in an opposite direction.

URALITE. Uralite is a pseudomorphous formation of hornblende after augite, the form of the latter mineral being retained.—E. SVEDMARK, *Jahrb. für Min.* 1877.

URALITE PORPHYRY. A microscopical examination of the uralite porphyry of Vaksala proved it to consist principally of a dark green diorite-like ground mass, with interposed plagioclase, hornblende, and uralite.

The uralite of Vaksala never occurs microlitic, and is of two colours, green and brown—sometimes both colours on one specimen. Sections made parallel to the vertical axis rarely exhibit any fibrous striation, but appear to be built up of broad or narrow columnar prisms, whence the uralite of this district differs from that of other localities.—E. SVEDMARK, *Jahrb. für Min.* 1877.

URENA. A genus of *Malvaceæ*. They are woody annuals. They possess mucilaginous properties, and their inner bark affords an abundance of fibre resembling jute.

URTICACEÆ. A natural order of dicotyledonous plants, of which the common stinging nettle forms the type of them. The plants of this order, which have a general distribution over the world, are trees, shrubs, or herbs, some being mere weeds, others large trees yielding useful and delicious fruits, as the fig, banyan, mulberry, &c., and some are useful for the fibre of the bark; the *Böhmeria* (which see), the Rhea or Chinese grass-cloth plant, belongs to this last class. One species, called *U. tuberosa*, has tuberous rootstocks, which are eaten by the native Indians either in a raw state or cooked. This plant was introduced into England, thinking the root would prove a useful article of food for cattle, but it could not stand the English winter. The

U. tenacissima is a very important species; it abounds in a ligneous fibre, which may be converted into very strong cordage: it is proved to be one of the strongest of the vegetable fibres. There is another *Urticaceæ*, the fibre of which is used in the manufacture of lace for ladies' shawls, &c., and is almost as fine as the best Shetland wool.

Urtica Utilis.—Ramee hemp is made from the fibres of the *Urtica utilis*, a native of Borneo, Sumatra, Java, and some of the smaller Sunda Islands. These fibres average about 1·5 to 2·2 metres in length. They are naturally of a bright yellow white colour, readily bleached to a perfect white, but are not much used on account of an inherent stiffness, which, as far as present experience goes, cannot be removed: the natives make cordage of the fibre, but it is of inferior strength, and does not well resist the action of sea-water.

V

VALONIA. (Vol. iii. p. 1053.) Imported in 1875 and 1876—

	1875		1876	
	Tons	Value	Tons	Value
From Greece	1,644	£40,200	1,084	£17,035
„ Austria . . .	696	18,432	—	—
„ Turkey . . .	22,063	502,518	33,802	611,093
„ other Countries . .	32	869	37	724
Total . . .	24,434	£562,019	34,923	£628,852

We exported of this—

	1875		1876	
	Tons	Value	Tons	Value
To Belgium	202	£5,730	427	£8,199
„ Australia	—	—	159	3,151
„ other Countries . . .	212	5,684	201	3,572
Total . .	413	£11,414	787	£14,925

VANADIUM. (Vol. iii. p. 1053.) Vanadium has been found in trap rocks by Dr. Apjohn (*Journal of the Chemical Society*, vol. x. p. 1116), and by Mr. R. J. Hodges in the iron ores from country Antrim, Ireland (*Chemical News*, vol. xxvi. p. 238).

Dr. James Blake forwarded to Professor Roscoe from San Francisco an ore of vanadium which he discovered in a gold mine, serving as a matrix for the gold. It occurred in small bunches filling cavities in a schistose porphyry.

This mineral occurred in radiating and foliated talc-like masses, greenish grey in bulk, and light greenish yellow when seen in fragments forming a grey powder. Its lustre is subvitreous to fatty. Its hardness is about equal to that of talc. Its specific gravity is 2·902.

The result of two analyses made by Professor Roscoe gave—

Silica	41·25
Vanadium pentoxide	28·60
Alumina	14·14
Iron sesquioxide	1·13
Manganese sesquioxide	1·15
Lime	·61
Magnesia	2·01
Potash	8·56
Soda	·82
Water	1·08
Moisture	2·27
	101·62

Dr. Blake says: 'At the suggestion of my friend Professor Gibbs, I propose to name the mineral "Roscoelite," should the name not be already appropriated.'

Professor Roscoe has examined another vanadium mineral found as a crystalline incrustation on the sandstone of Alderley Edge, and at Mottram St. Andrew's, in Cheshire. The compact mineral is purplish-brown or brunse. The lustre of the crystals is resinous streak yellow. Hardness about that of calc spar. Specific gravity 5·894. Its composition is found to be—

Vanadium pentoxide	17·14
Lead oxide	50·97
Copper oxide	19·10
Oxides of Fe, Zn, Mn	2·52
Lime	2·15
Magnesia	·26
Water	3·63
Moisture	0·22
Silica	1·03
	97·03

Professor Roscoe proposes to call this mineral 'Mottramite.'—*Proceedings of the Royal Society*, vol. xxv. p. 109.

Professor Roscoe, to whom we are indebted for all the chemical facts connected with vanadium, says:—'All the main facts now established in connection with the chemical department of this element proved it to bear a strong analogy to the elements phosphorus and arsenic. In fact, it occupied a previously vacant place in a well-defined group of triad, or as some chemists prefer to consider them, pentad elements. There was a property of vanadium in virtue of which it might ultimately attain considerable importance in the arts—though in the present infancy of the history of the metal it was difficult to foretell this with any certainty. This property was the power of forming a permanent black for dyeing purposes. The black produced by the action of vanadium had this advantage over copper and aniline blacks, viz. that it was permanent, whereas the latter were liable to turn green. This application of an element that was first introduced to notice as a chemical curiosity furnished one more example of the importance of original scientific investigation. However far a newly-discovered substance might seem to be removed from purposes of practical utility, we never know at what moment it might be turned to account for the benefit of the human race.

'*Mottramite*,' says Professor Roscoe, 'is interesting as forming the third term in a second (doubtless) isomorphous group of phosphates, arsenates, and vanadates, corresponding to the well-known *pyromorphite*, *mimetesite*, and *vanadinite* group. The new group is—

Dihydrite	$Cu^3P^2O^8 + 2Cu(OH)$.
Erinite	$Cu^3As^2O^8 + 2Cu\ (OH)$.
Mottramite	$(CuPb)^3V^2O^8 + 2(CuPb)\ (OH)^2$.'

Proceedings of the Royal Society, vol. xxv. p. 112.

Vanadium, used in preparing aniline black. See Aniline Black.

VANADINITE. From *Vanadis*, a cognomen of the Scandinavian goddess Freia. The vanadate of lead of Wanlock Head has been long known and usually classed with *vanadinite*. An analysis by R. D. Thomson gave—

Vanadic acid	23·44
Oxide of lead	66·33
Lead	7·06
Hydrochloric acid	2·45
	99·28

Bristow's *Glossary of Mineralogy*.

The formula for vanadinite requires 78·4 per cent. of oxide of lead.

According to Frenzel the mineral occurs in small light grey to yellowish or brown botryoidal masses, with a weak resinous lustre, specific gravity 6·75 at 20° C., and attached to calamine and ferruginous quartz. Freed from all impurities this mineral gave—

Oxide of lead	72·12
Vanadic acid	22·40
Phosphoric acid	4·70
	99·22

Most specimens contain small amounts of chlorine. Pure vanadinite occurs in the same locality in light yellow indistinct globules, or in barrel-shaped masses with rough surfaces. An analysis of these gave—

Chlorine	2·24
Oxide of lead	77·04
Vanadic acid	16·92
Phosphoric acid	2·72
	98·92

A. Frenzel, *Jahrbuch für Mineralogie*, 1875.

Vanadium, Bronze. The preparation known by this name is a vanadate of ammonium. On heating it in a sealed tube ammoniacal fumes are evolved, and a residue of vanadious oxide in black crystalline scales remains behind. Vanadium bronze is, therefore, not a metavanadite.—Anthon Guyard, *Bull. Soc. Chim.* xxv.

VANILIN. (Vol. iii. p. 1064, Vanilla.) M. Bouquet de la Grye has recently (September, 1876) sent to the Agricultural Society of France samples of vanillin derived from the sap of the pine. One of the samples was in the pure state, and the others were as prepared for the use of the confectioner.

Vanilin exists in the sap of the pine (*Pinus Sylvestris*) and of the larch (*Abies larix*). To obtain the sap the trees are felled in May and June, when vegetation is most active. They are stripped of their bark, and immediately scraped. The scrapings, which are collected in vessels of tinned iron, are immediately heated to prevent fermentation, filtered, concentrated, allowed to cool and settle. *Coniferin* is thus obtained, and from it the vanilin is extracted.—*Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, No. 33, September 1876.

Coniferin, $C^{16}H^{22}O^{8}$.—The glucoside contained in the cambium of the coniferous woods obtained as above stated is digested at 25°–36° C. with water and a small quantity of emulsin. It splits up into glucose and a substance which separates in white crystalline flocks, and after purification by solution in ether has the following composition: $C^{10}H^{12}O^{3}$. This acquires the odour of vanilla when exposed to the air or when oxidised with chromic acid mixture. The product shaken with ether and the ether left to evaporate, there remains an oil which on cooling solidifies to a substance identical in all respects with vanilla as obtained from the fruit of *Vanilla planifolia*.

This artificial vanilin cannot be produced at less cost than the natural product.—Tieman and Haarmann, *Deut. Chem. Ges. Ber.* vii. p. 608. *Dictionary of Chemistry*, By Henry Watts, 2nd Supplement.

VANILLA. Messrs. Tieman and Haarmann, the discoverers of the artificial vanilin, state in the *Journal of the German Chemical Society* that the various vanillas examined by them contained the following quantities of vanilin (the odorous principle of vanilla):—

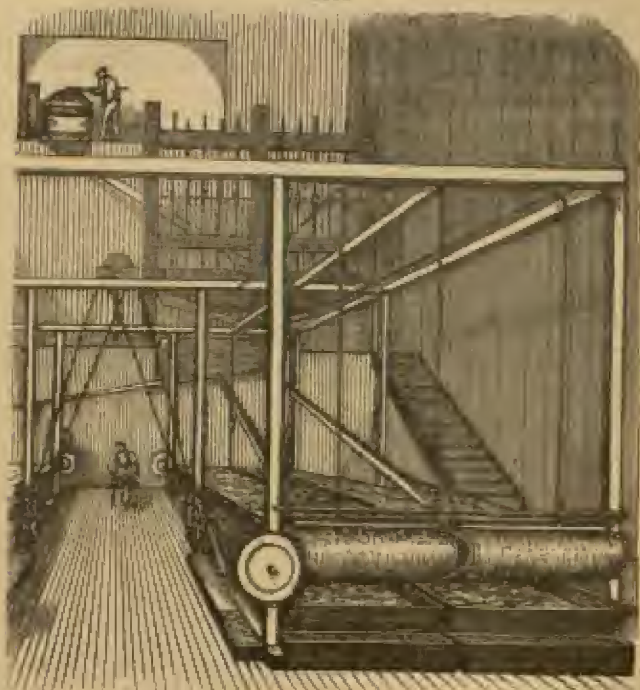
	Vanilin per cent.
Mexican vanilla (1873 harvest)	1·69
" " (1874 ")	1·86
" " medium quality	1·32
Bourbon, best quality (1874–75)	1·91
" (1874–75)	1·97
" "	2·90
" small medium (1874–75)	1·55
Java, best quality (1873)	2·75
" medium (1874)	1·56

VANNING MACHINE, OR ORE CONCENTRATOR. The 'Frue Vanning Machine, as it is called, is extensively used in the United States of America. It is in principle as follows:—

The dressing surface consists of a flanged rubber belt, slowly revolving against the descending stream of sand and water, and receiving a continuous lateral vibratory or shaking motion, which keeps the whole volume of water and sand in gentle movement. This side motion of the belt, the vanning, is the important feature of the machine;

and, in connection with the perfect surface of the rubber belt itself, is the real element of the success of the vanner on fine slimes. The BRUNTON belt in England, and the HOFFMAN belt in Germany, are known as slime dressers; the first is a self-discharging inclined plane in principle; the last, receiving in addition a succession of blows, is thought to be an improvement on the former, being an intermediate stage between it and the present vanning machine. The difficulty of making the belts last in the HOFFMAN machine was, according to the statement of the well-known manufacturing firm of KALK, near Cologne, the reason of the belt dropping out of use. In this machine no such difficulty occurs; the belt is of long duration, the only appreciable wear being caused by the attrition of the particles of ore passing over its surface with the water; and this wear, which is slight, is remedied by the occasional application of a liquid rubber paint.

2563



There are two forms of vanners in use, the single and the double. The first is a belt 27 feet 6 inches long and 4 feet wide, supported either in bearings or on toggles, within a stout wooden frame; both the side motion and revolving of the belt being run from a single pulley on the crank shaft. In the second form two belts are placed side by side, their supporting frames being bolted together and slung from above by iron rods, and both belts receiving motion from the same crank shaft and driving drum. The belts are in this case generally 33 feet 6 inches long by 4 feet wide.

In the mill above illustrated (*fig.* 2563, one side only being shown) the machinery consists of a 26 horse-power engine, BLAKE'S crusher, two TULLOCH'S automatic stamp feeders, and 10 stamps fed from a classifier below stamps. This mill, as also 7 others fitted with the vanners in Boulder County, is for the concentration of the low grades of tellurium ore. The average capacity of the mill is from 13 to 15 tons in 24 hours. The ore treated has varied in value from $10 to $100 per ton; where it carries tellurides and is worth $20 or $25 per ton, it pays well for freighting to the mill and for concentration. The average value of concentrations produced has been about $2,000 per month from actual sales to smelters. The value of the concentrations per ton varies of course with the value of the original ore and percentage of base minerals (mostly iron pyrites), some being as low as $80, others running up to $900 per ton. From the water tanks in which the collected mineral is deposited by the revolving

belt there is a gentle overflow of water into long settling boxes, in which settles the finely divided mineral suspended in the water. This 'float mineral,' as it is called, when working on regular tellurium ores, amounts to about 1 lb. per ton of ore treated, and is worth from $1 to $3 per lb. Assays made on 'tailings' or waste from the tables vary from $2 to $4·40 per ton. Five men, including two engineers, run the mill day and night; with water power three hands would be sufficient.

It may probably excite the surprise of those acquainted with the usual systems of concentration elsewhere in use to hear of an ore being stamped to a fine grain, run direct over a single machine, and then allowed to flow off as waste; but a little consideration of the character of tellurium ores will show the necessities of the case. In the low grade ores there is a fine impregnation of iron pyrites throughout most of the gangue, with intermixed fine patches and minute particles of the tellurides. A coarse crushing on such a rock is almost useless, for the mineral is not thereby separated from the particles of rock. The various tellurides of gold and silver, by reason of their state of division and brittleness, are not easy minerals to concentrate; but they can be and are saved by proper care. A higher percentage than most of the mills attain could undoubtedly be saved by the use of a second machine to treat the tailings of the first.

In the treatment of the black iron sand of Oregon the full effect and capability of the side shake in the vanning machine is most strikingly shown. Here is a coarse and heavy iron sand carrying minute spangles of free gold. The vibration of the belt affects strongly the coarser particles of sand, keeping them in quick motion, and therefore lightly suspended in the down-flowing water, while the fine flakes of gold sift down through the moving mass and, once touching the surface of the belt, are no more influenced either by the motion of the latter nor by the descent of water, but are carried up slowly by the moving bed and deposited clean in the collecting tank below. It is a generally-accepted maxim in concentration that the more uniform the size of particles in the matter treated, the better the separation effected. But a man skilled in the use of a vanning shovel will save cleanly nearly the whole of a mineral slime from an intermixture with quite coarse particles of rock. This is done by so regulating the motion of the shovel as to take advantage of the greater influence exerted by the moving water on the coarse pieces of rock than on the fine mineral clinging to the shovel's face. In fact, the flow of water regulated in this manner will move coarse particles of mineral almost as freely as coarse particles of gangue, still leaving the finely-divided mineral undisturbed on its bed: it is fully as much a question of surface exposed by the respective particles as of their specific gravity. This is the reason why the vanning machine has been able to save such fine mineral from an admixture with comparatively coarse gangue; the side motion multiplying the effect of the flowing water on the coarser material, assisting the settling of the mineral to the belt, and yet not disturbing it when once settled. In certain classes of work, especially where quantity is an object, it seems even preferable to have rather coarse sand go over the belt with the 'slimes'—say, for instance, all that will pass a screen of 40 holes to the lineal inch—the sand in this case forming a sort of bed, which, while tending to check the speed of the down-flowing water, is not allowed to become so heavy as to interfere with the perfect settling of the fine mineral. With the black iron sands one vanner can treat as much as 12 tons in 24 hours; but there are some impalpable slimes on which 2 tons in 24 hours would be fair work, owing to the volume they occupy. In a number of cases 5 and 6 tons in a day is the usual work.

VARIATION OF MAGNETIC NEEDLE. Sir George B. Airy issued the following card of information from Greenwich for instructing surveyors on the order of the variations of the compass needle over these islands:—

Generally, it may be understood that the western declination is now diminishing at the rate of 1° in eight years.

A magnetic survey of an entire kingdom is an operation so troublesome that it is impossible that it can be made very frequently, and we are in practice compelled to adapt the results of a survey made in one year to form, by application of a constant difference, results equivalent to those which would be obtained by survey in another year.

From Dungeness to North Foreland, magnetic westerly declination is 40′ *less* than at Greenwich.

From Shanklin (Isle of Wight) to the middle of the Wash, 20′ *more* than at Greenwich.

From the Start Point, by Bristol, to Whitby, 1° 20′ *more*.

From the Land's End, by Liverpool, to Holy Isle, 2° 20′ *more*.

From Douglas (Isle of Man), by Kirkcudbright, to Leith, 3° 20′ *more*.

From Youghal (Ireland), by Newry, Belfast, and Bute to Inverness, 4° 20′ *more*.

From Tralee, by Galway and Londonderry, to Cape Wrath, 5° 20′ more.

From Achil Head to the western part of the Lewis, 6° 20′ more.

If these differences are applied to the declination at Greenwich, the declination on each of these lines will be obtained with great accuracy. And with the assistance of a map any of your correspondents will be able to find the declination for his own locality.

The variations for several years have been—

1863.—January, West declination	. . . .	20° 50′
,, July ,, ,,	. . . .	20° 47′
1864.—Interrupted.		
1865.—February ,, ,,	. . . .	20° 31′
,, July ,, ,,	. . . .	20° 31′
,, December ,, ,,	. . . .	20° 33′
1866.—July ,, ,,	. . . .	20° 26′
,, December ,, ,,	. . . .	20° 22′

The magnetic elements for 1877 were—

Declination (or variation of the compass)	. . . .	19° 3′ W.
Inclination (or dip of the needle)	. . . . . .	67° 27′
Horizontal Force, measured in British units	. . .	3·90
Vertical Force ,, ,, ,,	. . .	9·49
Total Force ,, ,, ,,	. . .	10·26

VARIATION OF PRESSURE IN GAS. Pressure registers are requisite in all such establishments as desire to conduct photometric experiments in a satisfactory manner, and these gauges are often required to determine—as in gas-meters—the rate of the flow of gas through the pipes. Several instruments have been introduced from time to time, but the pressure-gauge usually known as 'King's' is that which is most usually adopted. This is made upon the principle of the ordinary inverted syphon, the leg, or well, open to the atmosphere being sufficiently enlarged to admit of a small float rising and falling without adhering to the side of the tube. Above the well, and with its edge over the centre of the opening, is fixed a wheel, the circumference of which is double, or rather more than double, the length of the extreme height to which the water could rise or fall. Over the grooved periphery of the wheel a light line is passed, one end being attached to the float and the other to a counterpoise, consequently any motion in the water was imparted through the line and the float to the wheel. Upon the shaft of this wheel a pointer is fixed, the length of which magnified the motion of the wheel, so that the rise of an inch of water in the well is shown upon a much-increased scale on a dial, supported by a pillar on each side of the well, the centre of the dial being also the centre of the wheel. The pressure-gauge is also provided with an apparatus for altering the water level, without in any way interfering with the photometer to which it is attached. This is simply a solid plunger closely fitting to the inside of a cylinder, the middle of which is level at the true water-line of the pressure gauge. Above the plunger is fixed a screw, which either raises or depresses the plunger, and produces a contrary action on the water-line of the pressure-gauge, so that the pointer can be brought to the zero point with speed and accuracy. Some interesting experiments with this pressure-gauge and a self-registering photometer, the registration being made by photography, will be found in Gas Manipulation, by William T. Sugg.

VARIOLARIA DEALBATA. A lichen from which a violet colouring matter is obtained. In 1829 M. Robiquet succeeded in extracting from this lichen a colourless crystalline saccharine, yet astringent, substance, which he termed orcine. He found that orcine, under the influence of air and ammonia, fixes nitrogen, and becomes converted into a violet-coloured matter. Orcine may be prepared by various processes. Robiquet obtained it by exhausting variolaria with boiling alcohol: this liquid deposits, on cooling, crystals, which are first removed, after which the fluid is evaporated to dryness. The dry residue treated with boiling water yields on concentration crystals of orcine. Dr. Stenhouse extracts the lichens in milk of lime, boils and concentrates the liquid, precipitates the lime by carbonic acid, evaporates the liquid to dryness, and takes up the residue with concentrated boiling alcohol. The crystals of orcine which separate from this liquid, on cooling, are re-dissolved in pure anhydrous ether. The best process for preparing orcine is that described by M. de Luynes. Lima lichens are exhausted with milk of lime, the filtered liquid is precipitated with hydrochloric acid; the erythrine thus obtained is washed, and next heated for two hours in a closed iron vessel at 150°, along with a certain quantity of milk of lime, too small to effect the entire decomposition of the substance. The car-

bonate of lime having been separated by filtration, the liquid is evaporated slightly, when, on cooling, orcine separates in the crystalline state; the evaporation of the mother-liquid yields a crystalline magma, consisting of erythrite and orcine, which latter is removed by means of ether. The erythrite is purified by solution in boiling alcohol, from which it crystallises on cooling. The calcareous extract may also be boiled, in order to concentrate it; the lime may be removed by carbonic acid; the liquid, after removal of this deposit, is evaporated to dryness, and treated with ether to remove the orcine. Dr. SCHUNCK obtains orcine by boiling lecanorate of baryta with water for a long time; carbonate of baryta is precipitated, while orcine remains in solution, and is purified by repeated crystallisation.

VARNISH, GREEN. A very excellent green varnish for metals may be thus prepared:—

Finely pulverised gum sandarach or mastic (the latter, however, is too expensive for some uses) is dissolved in strong potash lye until the alkali will dissolve no more. The solution is diluted with water and precipitated with a solution of sulphate of copper. This green precipitate is washed, dried, and dissolved in oil of turpentine. This produces a green varnish which does not change under the effect of light, and will be especially useful for ornamental iron work.—*Industrie Blätter.*

VARNISH, JAPANESE.—Japanese varnish is obtained from a tree, *Rhus vernicifera*. This varnish tree, which is called *urushi noki* by the Japanese, reaches a height of 33 ft., and at the age of 40 years the trunk is 40 in. in circumference, grows very slowly, about 13 in. per year in height. The wood is strong and heavy, has few branches, consequently very little foliage, and the tree is not very pleasing to the eye. The fruit resembles grapes, and grows in thick spikes on the branches. In October the fruit is ripe, and is collected in November to obtain from it a vegetable wax, known as Japanese wax. The tree is best propagated from the root shoots. It reaches its greatest perfection at its eighteenth year, and then produces the largest yield of lac or varnish. This is obtained by slitting the bark in a horizontal direction, and may be performed at any time between April and October; later in the year the lac is very thick and viscid, so that its collection is attended with much greater difficulty. The lac tapper carries his own peculiar bow-shaped knife, made for this purpose, with which he makes a 2-millimètre (8-100ths inch) cut in the trunk of the tree in a horizontal direction, and then draws the point of the knife through the cut again, to remove any chips formed by the first cut. This cut is made low down; on the opposite side of the trunk, 15 or 20 cm. (6 or 8 in.) farther up, a second cut is made, then on this side again, and so on until the trunk has 9 or 10 such cuts. After he has cut 10 or 15 trees, he returns to the first tree and collects the sap oozing from the cuts, which sap is light grey, and thick; but by exposure to the air it at once turns dark brown and afterwards quite black. The crude lac is called *ki-urushi*.

The tree is hacked in this way for 60 to 80 days, until it dies; it is then cut down, the wood chopped up and put in hot water, which extracts the last remnant of the sap. From the tree when cut down, ¼ litre of sap is obtained, and this forms the poorest kind of lac. The value of 100 lac trees is about $30 to $40.

The lac is purified in the following manner:—It is first filtered through cotton stuff, ground on a paint stone like ordinary paints, mixed with water, and the water evaporated again by warming. The finer sorts are bleached in shallow dishes in the sun. The best kind is called *nashyi-urushi*, the poorer kind *hanki-urushi*, the unbleached *jeshime-urushi*. The black varnish, *roiro-urushi*, is made from the crude lac, *ki-urushi*. There are about twenty different kinds in market, of which the above-named are most used. The cost in Japan is: *nashyi-urushi*, $4·77 per lb.; *jeshime-urushi*, $1·65 per lb.; *roiro-urushi*, $5·70 per lb. The Japanese varnishes are often adulterated in trade.

The operation of varnishing is conducted differently from what it is in Europe. The Japanese apply their varnishes mostly to woodwork, less frequently to copper and unglazed stoneware and porcelain. When applied directly to tinware the japan does not stick; a preliminary gelatinous wax is therefore applied. The varnishes are generally brilliant black, dark coloured, impure vermillion, or impure dark green, or dark grey. Pure light colours and white cannot be produced with Japan varnish.

The Japanese varnishers prepare their woodenware with the utmost care; the surfaces are smoothed and the chinks filled with cement. The ground coat is a mixture of *jeshime-urushi* with paste; upon this is laid Japanese paper, rubbed smooth with a brush, and dried. Afterwards several very thin coats of the same varnish, now and then well dried, and, after every coat, polished with Japanese carbon.

The drying is performed in a moist atmosphere. For this purpose they take a box that will shut tightly, put the articles to be dried in it, close the box and wet it on

all sides with water. After 24 hours one coat is dried. If the articles are to be black, it is now given a coat of black varnish, *roiro-urushi*, but if it is to be grey or grey-brown, *jeshime-urushi* is used instead, and if it is to be red, the latter varnish is mixed with vermillion. The appearances of gold and pearl are obtained by mixing real gold dust, or mother-of-pearl dust, with the varnish, whereby a beautiful effect is produced. It is then dried, rubbed down, and polished; and if there are gold, tortoise-shell, or mother-of-pearl decorations, another coat of azure varnish, *nashyi-urushi*, is applied. Dr. Rex communicated other methods of japanning, but most of them are analogous to those described.

In applying their varnishes the Japanese use broad brushes, the bristles of which are very stiff, and inserted in wood. After long use the bristles get worn short, and the wood is cut away as in sharpening a pencil, exposing more of the bristles. A very fine piece of work receives eighteen coats; these never fade with time but rather improve, bear a high heat, and are quite unaffected by acids, spirits, or the like.

VASELINE. (Syn. *Saxoleum purificatum.*) Vaseline is a pale yellow, translucent, slightly fluorescent, semi-solid body, melting at 37° C. Specific gravity ·840 at 55° C. It is inodorous, non-volatile at ordinary temperatures, but distils with slight decomposition under pressure. It is insoluble in water, slightly soluble in alcohol, freely in ether, and miscible in all proportions when melted with fixed or volatile oils. It mixes in all proportions with glycerine of the ordinary strength, but the mixture is destroyed by addition of water. Hydrochloric acid and liquor potassæ are without action upon it.

Vaseline, it was thought, might be a mixture of paraffin and glycerine. A quantity was accordingly boiled with water for some time by Mr. Moss, the aqueous liquid filtered from the seeming oily portion, and evaporated to dryness, when it became apparent that not only was the body free from glycerine, but also from all but very minute traces of anything soluble in water. Before evaporating, the liquid was found to be without action on red and blue litmus.

In order to test the accuracy of the conclusion arrived at on the first examination, viz. that vaseline is a mixture of paraffins, an ultimate organic analysis was made by burning 0·134 gram of vaseline with lead chromate. The carbonic acid gas and water obtained respectively corresponded to 0·1124 gram carbon and 0·0183 gram hydrogen, the two together forming 97·54 per cent. of the whole.

On drying at 120° C. the vaseline lost 0·5 per cent. of water, and on ignition it left 0·05 per cent. of ash.

The composition of vaseline is therefore—

Hydrocarbons (*paraffins?*)	97·54
Moisture	·5
Ash	·05
	98·09

Under the microscope vaseline is seen to contain numerous minute needle-shaped crystals; the number of these increases as the temperature is lowered, and there is no reason to suppose that on an ordinary cold winter's day the mass would not be wholly crystalline. One ounce of vaseline was boiled with successive portions of absolute alcohol until traces only were dissolved. The alcoholic solutions united gave 60 grains of an almost colourless residue, which melted at 29·5° C. Vaseline itself melts at 37° C.; this part of it, therefore, is less likely to be crystalline than the bulk, yet crystals could be easily discovered in it with the aid of the microscope, and, by dropping ether on the back of the slide, the temperature was so reduced that crystals filled the field. The part not dissolved by alcohol (85 per cent. of the whole) having a much higher melting point than the above, was also found to be mainly crystalline, and this without cooling. Vaseline was examined as to its crystalline or amorphous condition, because of statements by the manufacturer and others that it will not crystallise. The importance thus attached to absence of crystalline character was due to the fear of irritation by the edges of the crystals when applied as an ointment to wounds with sensitive surfaces, but it is in apparent forgetfulness of the fact that solid vegetable and animal fats generally have the character which it has been shown that vaseline possesses. The possession of this character constitutes another though not very important feature, in which vaseline resembles the paraffins. Vaseline, then, consists almost entirely of *hydrocarbons*; it is not at all affected by most chemical bodies, and only slowly by the more powerful among them; by distillation under pressure it is resolved into bodies having lower melting points; *it is obtained from the residue of the distillation of American petroleum*, and is of a crystalline character. All these characters pertain to paraffins, and the justness of the above

conclusion is consequently emphasised by the result of the combustion, and by the microscopical examination.

Paraffin does not form a soap when boiled with caustic lye. A rough experiment was made by boiling 100 grains of vaseline with 7 fluid ounces of solution of potash (1·15) for half an hour. A little vaseline was lost by spirting, but that recovered weighed 97 grains, after washing and drying. No soap was found in the lye. Vaseline, therefore, does not saponify.—John Moss, F.C.S., in the *Pharmaceutical Journal.*

Another chemist of considerable eminence, who has a large practical acquaintance with the paraffins, has obliged us with the following statement, which confirms the examination made by Mr. Moss:—

'Vaseline has no relation whatever with glycerine. It is a bright, pale orange-coloured material, clean, soft, and slightly tenacious, without smell or taste. It is insoluble in water and alcohol, is soluble in ether, does not form a soap with alkali by any short treatment. When heated it distils with the usual smell of decomposing fatty and hydrocarbon materials, the fluid browning slightly. Heated more strongly it takes fire, burning freely at first, then with difficulty and with a smoky flame, leaving some pitchy residue.

'From these indications it was judged to be substantially a hydrocarbon—possibly a late product of the distillation of mineral oil, or a mixture of such material with a resinous substance.'

The process of manufacture is briefly as follows:—The crude oil is highly concentrated, the lighter hydrocarbons being driven off by simple heat without distillation; the product is then carefully and repeatedly filtered through bone black or animal charcoal, just as syrup is treated in the process of sugar refining, and the result is a pale yellow or pearly-white substance (according to the length of the treatment) having the consistency of butter, absolutely free from odour and chemically pure. This process, discovered by Mr. R. A. Chesebrough, is the subject of patents in America, the United Kingdom, France, Belgium and Germany, by the Chesebrough Manufacturing Company, who have the sole right of working it, and who have introduced the product into commerce under the name of vaseline. The derivation of this name has not yet transpired, but as the patentee was of opinion that the article contained no paraffin, it may be supposed that he believed it to be an oily substance, and indicated his creed in the name bestowed upon it, which we surmise to be derived from the Greek φασω, I believe, and ἔλαιον, oil. Be that as it may, in whatever way vaseline came by the name, it is a very taking one, and has already become so well known that any attempt to replace it, even for purposes of prescribing, must end in comparative failure.

Vaseline has important chemical relations, for whilst lard is an oxygenated body and becomes rancid with peculiar and provoking facility, vaseline is made up solely of hydrocarbons belonging to the paraffin series, hence it contains no oxygen and defies decomposition except by the most powerful agents, such as strong nitric acid or heat. It may, therefore, be used in any case, or for any purpose, instead of lard, if we exclude those instances where the decomposition of the latter furnishes an element in the result desired, as in the ointment of nitrate and oleate of mercury. It will be obvious that we speak of lard here mostly as typical of vegetable and animal oils and fats. Pharmacists who have had stocks of ointment turn rancid on their hands will be able to appreciate the advantages of a base which is proof against such powerful decomposing influences as exposure to air, damp, and the catalytic action of the numerous unstable agents incorporated into ointments, liniments, embrocations, plasters, bougies, pessaries, suppositories, cold cream, and not least, pomades.

VEGETABLE PARCHMENT. An improved form of vegetable parchment, which was introduced some years since by Messrs. De la Rue and Co., has recently been brought into the market. The improvement consists in rendering the parchment elastic and pliable by impregnating it with glycerine. It is said to be quite impervious to moisture.

On the Tensile Strength of Vegetable Parchment.—'The experiments described in this paper were made with a view of furnishing additional information in regard to the so-called parchment paper, of which the knowledge has hitherto been imperfect and without numerical data. The material experimented upon was pure cotton paper, made by E. Dietrich, of Helfenberg, near Dresden.

'The production of parchment paper is effected by running the web of unsized paper, as it leaves the machine, through a mixture of sulphuric acid and water, after which it is carefully washed to remove the acid. At the works in question the acid bath contained 9 to 9½ parts of English sulphuric acid of 65° to 66° B. to 1 of water, the weight of the mixture being about five times that of the paper treated. The temperature of the bath is kept down to 10° C., and the time of immersion is three

seconds. These factors are, however, liable to variation according to differences in the raw materials operated upon.

'The change effected by the acid consists in a superficial conversion of the cellulose into a substance analogous to starch (the so-called hydrocellulose of GIRARD), which forms a cement closely uniting the unaltered fibres. This is accompanied by a contraction of area of from 5 to 10 per cent., and a loss of not less than 10 per cent. in weight.

'The results obtained by the author from the examination of three samples of the same paper, both before and after treatment with acid, are contained in the following table. The amount of moisture and ash were determined by Mr. MEUSEL, a student in the Polytechnic laboratory at Dresden:—

No.	Description	Thickness	Specific Gravity	Tensile strength per Millimetre in Kilogrammes	Hygroscopic Water. Per cent.	Ash. Per cent.
		Millimètre				
1	Plain paper	0·234	0·617	1·415	6·755	0·632
	Parchment paper	0·152	0·964	6·436	8·778	0·406
2	Plain paper	0·178	0·543	1·483	7·071	0·645
	Parchment paper	0·113	0·937	5·111	8·483	0·458
3	Plain paper	0·134	0·624	1·503	6·078	0·678
	Parchment paper	0·088	0·927	6·777	9·160	0·559

'The contraction in thickness of the paper by the treatment in acid varies from 34 to 37 per cent., while the increase in specific gravity is from 32 to 42 per cent.

'The increase in strength in the different samples was—

In No. 1	4·55 times that of the natural paper.	
" 2	3·44 "	"
" 3	3·84 "	"

'When parchment paper is softened in water for a short time, its strength is found to be diminished to about 0·6 as a minimum of that obtained when in an air-dried condition.

'The loss of ash is due to the action of the acid on the mineral matter in the fibre producing soluble salts, which are removed in the subsequent washing.

'The lower the temperature at which the operation is performed the stronger is the parchment paper obtained. It is, however, difficult to regulate the temperature, owing to the heat developed in the acid bath. For this reason the author did not think it necessary to make experiments upon this point, as the results could not be of any practical value for the carrying out of the process, which depends upon many contingencies that can only be controlled by the experienced eye of the manufacturer.' —A. LÜDICKE, *Civilingenieur*, vol. xii. p. 155; *Abstracts of Papers from Foreign Journals*, Institute of Civil Engineers.

VENERITE. This mineral occurs as a greenish earthy scaly mass with magnetite at Jones's Mine, Springfield, Mass., U.S. Its composition, according to Mr. G. W. HAWES, is—

Silica	30·73
Alumina	14·67
Ferric oxide	5·35
Ferrous oxide	0·29
Oxide of copper	17·58
Magnesia	18·55
Water	12·83
	100·00

American Journal of Science, September 1877.

VENTILATION. Mr. MARTIN TOMS, of Leeds, has drawn attention to a system of ventilation which requires some notice. His principle is, in the main, correct, but we are by no means certain that the same result may not be obtained by far more simple means.

We cannot present more satisfactorily Mr. Tobin's principle to our readers than by availing ourselves of some portions of a long notice which appeared in the *Times*, (Mr. Tobin's patent is dated March 24, 1873):—

'The solution of all these difficulties (ventilating a room), and the means of rendering the atmosphere of any chamber as pure as that outside the building, without improper lowering of temperature, and without the production of draught, has recently been discovered, and has been brought into practical application by Mr. Tobin, a retired merchant, who lives in the neighbourhood of Leeds. Mr. Tobin's own account of the matter is that he was once watching a current of water which flowed into a still pond. He observed that the moving water kept together, and held its own, until its course was arrested by the opposite bank, when it curved gently round on either side, and was lost insensibly in the general body, which had its outlet for overflow at one side. He reflected that a current of air introduced into a room would act in precisely the same manner, keeping together until it encountered an obstacle, then mixing insensibly with the air around it, and compelling an overflow wherever there was an opening available. He saw that, if this were so, it would only be necessary to give the entering current an ascending direction, so that it would reach the ceiling without impinging on any person, in order to solve the whole problem of domestic ventilation. Experiments at his own house confirmed his anticipations, and led him to contrive methods, which he has patented, of carrying his principle into practice. At that time the state of the Borough Police Court at Leeds was, as, indeed, it had been for some time previously, a source of great perplexity to the Town Council. The Court is one of a series of rooms which surrounds the Town Hall, and the doors opening into it are three in number—one leading from a corridor which gives access to the public, one leading into the magistrates' retiring room, and one from the cells into the dock. Light is admitted only by a window in the roof, and in this skylight there is an opening, intended for the exit of foul air, but practically serving for the entrance of fresh air. The court is liable to be crowded every morning by unclean visitors, and the heat and stench were such as to defy description. Through this heat and stench a stream of cold air fell down from above on the presiding magistrate, and occasioned him severe suffering. The justices were often compelled to make their escape before the business of the day was concluded; and the council had expended between 1,400*l.* and 1,500*l.* on successive ventilation doctors, each of whom had left matters as bad as, if not worse than, they were before. The subject was one of continual comment in the local papers, but the council had begun to despair of a remedy, when Mr. Tobin offered to supply one. He suggested that the council should pay him a nominal royalty for the use of his patent, and that they should pay the few pounds required for doing the work, leaving his own remuneration to their discretion when they saw the effect. These terms having been accepted, Mr. Tobin placed under the floor of the court three horizontal shafts which communicated with the open air through a cellar grating. From these he brought eight vertical shafts through the floor at different points. These vertical shafts rise about 4 feet above the floor, and are each 6 inches in diameter. They have open mouths, and are placed out of the way in corners, or against the partitions of the court. From each shaft there ascends to the ceiling an unbroken current of the outer air, like a fountain, or like a column of smoke when the barometer is high. The current will support feathers, or wool, or other light substances, and has so little tendency to spread laterally that it can be made to influence half the flame of a candle, while the other half remains undisturbed. A person resting his cheek against the margin of one of the tubes feels no draught, and the hand feels none until it is inclined over the orifice. The effect was instantly to render the court as fresh and sweet as the external air around the building. The steady flow of the eight ascending currents constantly rinsed out, so to speak, the confined space, and washed away the effluvia of dirty people, and the products of respiration, as fast as they were liberated, forcing them out through the skylight opening which was previously only an inlet, but which was altered in a manner to facilitate egress. After three months' trial, and after all the magistrates for the borough had joined in a report, which expressed their entire and unmixed satisfaction, the corporation voted Mr. Tobin an honorarium of 250*l.*, to express their sense of the benefit which he had conferred upon the town. They also applied his system to the council chamber; and their example was followed by some of the leading bankers and merchants, by the churchwardens of St. George's Church, and by the proprietors of the *Leeds Mercury*, who have had every room and office in their spacious premises ventilated under Mr. Tobin's superintendence, and who have expressed, in two or three descriptive articles, the entire success which has been obtained.

'The system of vertical tubes is necessary for rooms which have no side windows, or which have only a small window surface in proportion to their cubic contents. But Mr. Tobin at the same time contrived a cheap and simple method, by which vertically

ascending air currents can be introduced through common window sashes; and this method will suffice for all ordinary living or sleeping apartments. Each of the openings made for this purpose is provided with a cover by which it can be closed at will; and they admit of a method of securing the sashes which affords almost entire security against burglars. A very competent authority has communicated to us his experience for eight weeks of a room containing 2,500 cubic feet, ventilated, under Mr. Tobin's direction, by four window openings which have an aggregate area of 80 square inches, but which are filled by layers of cotton wool to filter the entering air from dirt and moisture. The currents ascend in absolute contact with the glass, keeping so closely to it that they do not affect the flame of a taper which is held vertically in contact with the sash bar; although, as soon as the taper is inclined towards the pane its flame is strongly fluttered. In this way the air ascends to the top of the window, where it is directed to the ceiling and lost as a current, being no longer traceable by taper, hand, or fragments of down, although closing the window openings diminishes in a marked manner the draught up the chimney. Each opening, as already described, has an independent cover, and, without the wool, the four would, in cold weather, be too much for a room of the size specified. With the wool they do not perceptibly diminish the temperature, but they give a feeling of absolute out-of-doors freshness, which must be experienced in order to be appreciated. There is no draught anywhere, and the openings are not visible unless sought for, so that curious inquirers who have remarked on the result have been unable to find the inlets. Arranged as described, the openings are sufficient to feed a large argand table gas burner, and to sweep away entirely the products of its combustion; so that, when the room has been shut up, with the gas lighted and with a good fire, for three or four hours, persons entering it from the open air are not able to discover, except by the greater warmth, any change of atmosphere. A bedroom ventilated in a similar manner is as fresh when the door is opened in the morning as when it was closed at night.

'Mr. Tobin's experiments early led him to the conclusion that the prevailing notions about the necessity for carefully planned outlets were fallacious, and that, if proper inlets are provided, the outlets may generally be left to take care of themselves. In order to test this he fitted two vertical tubes into a small room which had a fireplace and a three-light gas pendant. He closed the opening of the fireplace, and every other opening into the room except the tubes, hermetically, and, shutting himself within, pasted slips of paper all round the door. He found that there was then no entrance current by the tubes. The room had no outlet; it was full of air, which his respiration had not had time to consume in any appreciable quantity, and no more could get in. He next lighted the three gas burners, and a steady entrance current immediately set in through the tubes, and continued as long as the gas was burning. He waited nearly an hour without any deterioration of the atmosphere becoming perceptible to his senses, and with the currents steadily coming in and ascending in their customary manner. He then cut through the paper which secured the door, and left the room, shutting the door behind him. Returning half-an-hour later, he found the atmosphere still fresh. He next extinguished the gas, and the currents gradually died away, the original state of equilibrium or fulness being restored. This experiment, which has been several times repeated, seems to show that the external air will enter just in proportion as room is made for it by combustion or respiration, and that the rate of supply is essentially governed by the rate of destruction or demand. In the closed room the water produced by combustion would probably be condensed, and the heavy carbonic acid would sink to the floor. If the combustion continued indefinitely, the accumulation of these products would in time render the air 'irrespirable;' but that time would be much longer in coming than is generally supposed, and, for all practical purposes, the chimney throat is everywhere sufficient as an outlet.

'The *rationale* of the matter appears to be that when the external air communicates with that of a room through a channel which terminates in a vertical shaft, an inward current is produced as soon as the air of the room is either rarefied by warmth or partially consumed by respiration or combustion. This inward current is due to the pressure of the external atmosphere, which is capable of driving the entering air, in a compact column, to a considerable elevation. The whole pressure of the atmosphere is equal to rather more than 14 lb. on each square inch; and this force would be all exerted if the chamber into which the air was to be driven was itself a vacuum. As it is, the pressure exerted will always be determined by the difference between the atmospheric density within and without the chamber; and hence, the more the internal air is rarefied or consumed, the greater will be the force of the entering current. It follows that the supply of air adjusts itself automatically to the demand, and that the inlets should always be sufficient for the maximum requirements of the room to which they

are applied. However large they may be, they will not admit air in excess of the rarefaction or combustion of that which is already there; and, as rarefaction and combustion diminish, the number of cubic feet passing through the inlets in a given time will diminish in precisely the same ratio.

'In order to obtain an absolutely perfect result it is necessary to bear in mind that the behaviour of the entering current will be precisely like that of the vertical column of water sent up by a fountain, except that, as the ascending air is received in a fluid of only little less density than its own, it will mingle with that fluid gradually when the propulsive force is exhausted, instead of falling almost vertically by the action of gravity. But just as a fountain, if it encountered an obstacle while its column was still compact, would rebound from that obstacle with considerable violence, so the entering current of air, if it meet with an impediment prematurely, will be reflected as a draught. We have seen this very well exemplified in a room at Leeds, in which the construction of the windows rendered it necessary to make the inlets much higher up than usual, and in which, when the force of the entrance current was increased by lighting gas, a very distinct stream of cold air was reflected from the ceiling. To prevent such an occurrence, it is necessary to make the inlets so low down that, under all ordinary circumstances, the force of the stream will be expended before the ceiling is reached; and when, from any circumstances, this cannot be done, the current may be broken by strainers of wire gauze or other suitable material. In this, as in most other matters, some special adaptation of means to ends is required; and the arrangements for any given room must be planned by some one who has practical knowledge of the subject.'

VERDIGRIS. (Vol. iii. p. 1071.) Common green verdigris is a mixture of the sesqui-basic and tribasic salts of copper. It is prepared by repeatedly sprinkling copper plates with vinegar in a warm room.

In calico printing, acetate of copper (verdigris) is used in solution, and is prepared by the double decomposition of sulphate of copper and sugar of lead. The following mixture is often employed: 1 gallon of water at 160° Fahr.; 4 lb. white sugar of lead; 4 lb. sulphate of copper. The ingredients are previously ground up, and the mixture is frequently stirred till the decomposition is complete, when the sulphate of lead is allowed to deposit, and the clear liquid is drawn off. The respective proportions of sulphate of copper and of sugar of lead are varied in different establishments, some using 2 lb. only and others as much as 6 lb. of sugar of lead to 4 lb. of sulphate of copper. It is obvious that where the smaller proportions of sugar of lead are used, the resulting solution must contain a considerable quantity of sulphate of copper mixed with the acetate.

The uses of verdigris are less extensive than was formerly the case. It is used in many catechu colours, in certain resists for indigo blues, and as an oxidising agent in a few steam colours. In black dyes for silks and for hats and for printing blacks on silk goods, verdigris is also employed. Logwood blues on wool are also dyed with an admixture of salt of copper, generally verdigris. The Act of George III., 20, which imposes a penalty of 20*l.* for every piece of cloth dyed blue by means of this process, is a curious specimen of the commercial legislation of our forefathers, and is supposed to be still unrepealed. Verdigris figures in a great variety of old dyeing receipts, where its utility is exceedingly doubtful; or rather where its inutility has been satisfactorily demonstrated.

VERMILLION. *On the Degradation of the Colour Vermillion, occasioned by contact with Copper and Brass.*—'Some years ago, Karmarsch (Ding. *Polyt. Journ.*, clxxxvi. p. 163) investigated the circumstance that if copper plates are employed in printing vermillion, the impressions are generally brown or blackish. In the manufacture of playing-cards it has also been observed that if brass is used in grinding up the colour, its beauty is seriously impaired, the red becoming at first brownish, and very soon deep brown, and utterly useless. Karmarsch perceived at once that this change of colour depended on the formation of copper-sulphide, but supposed that the requisite sulphur was derived from impurities in the vermillion, as a decomposition of the latter under such circumstances, at ordinary temperatures, is highly improbable.

'M. Hermann having recently shown that this decomposition of vermillion actually occurs, regards Karmarsch's proposal, to boil the vermillion before use in a solution of pure potash, as useless, and he has therefore repeated the experiments of the latter chemist.

'The author had at his disposal a very pure vermillion, perfectly free from metallic mercury, which, when boiled with solution of potash, left it quite colourless, and yielded to it no demonstrable traces of sulphur. Nevertheless a bright plate of copper or brass was immediately coated with black copper-sulphide, if the vermillion previously extracted three times with fresh potash lye and then washed, was rubbed upon it with a cork. Perfectly dry vermillion requires a somewhat strong pressure

to produce this effect. If it is previously rubbed up to a paste with water, pressure with the finger is sufficient to blacken the copper. On stronger friction with a cork, a part of the black coating becomes separated from the metal, mixes with the rest of the vermillion and gives it a blackish colour; whilst the copper, where it has been in contact with the vermillion, is strongly amalgamated. It is even possible to write upon copper or brass with a piece of sublimed vermillion, the characters appearing silvery white after the metal has been rinsed in hydrochloric acid. The ready decomposability of vermillion, as shown by this experiment, cannot be removed by boiling in potash. KARMARSCH, however, declares that commercial vermillion may be freed by two methods from those sulphur compounds which, in his opinion, cause the formation of copper sulphide—first, by boiling with potash lye; and secondly, by stirring up the vermillion to a paste with water, and introducing pieces of metallic copper, which were to seize upon the sulphur and thus deprive the vermillion of the power of blackening any further quantity of copper.

'This result can only be explained by assuming that in his experiments qualities of vermillion were used which really contain soluble sulphur, by which the copper was affected, whilst the vermillion was not in such close contact therewith as to undergo decomposition. Following KARMARSCH, HEEMANN laid a bright copper coin for some time in a paste of vermillion and water, and found, on rinsing it, that the metal was really almost unchanged. Those places only which had been accidentally touched with a glass rod in stirring up the mixture were blackened. Wherever the copper had come in collision with the side of the vessel within the paste, thus occasioning close contact between the metal and the vermillion, blackening and amalgamation of the metal were manifest. The results of KARMARSCH's experiments are possible only if the pieces of copper remained motionless in the colour paste, and thus were able to take up merely free or dissolved sulphur.

'As in printing, &c., with vermillion, the contact necessary for the decomposition of the metal occurs; the degradation of the colour cannot be prevented by previous boiling with potash. Vermillion rubbed up with oil is much less readily attacked than if dry or mixed with water. Iron decomposes vermillion only at elevated temperatures, and can therefore be used for rubbing and grinding without injury to the colour. Zinc has a very slight decomposing action if rubbed with vermillion, and the zinc sulphide, if formed, is white; the change of the red colour is scarcely perceptible.

'KARMARSCH states, in a note to his *Memoir*, that extraction with potash lye is not to be recommended for all sorts of vermillion. One sample was rendered decidedly brown by this process. A sample of vermillion prepared in the moist way was sought to be freed from an admixture of metallic mercury by boiling with dilute nitric acid, in consequence of which it assumed a lighter colour, and on subsequent treatment with caustic or carbonated alkalies or ammonia it became a deep black. In consequence of the action of mercuric-nitrate upon a portion of the vermillion, there was formed the white compound—

$$(2HgS+Hg(NO^3)^2),$$

which made the red colour rather paler, and, on decomposition with alkalies, yielded a black mixture of mercuric oxide and mercuric sulphide.'—R. HEEMANN.

VESUVINE. This colour was discovered by KNOOP, of Stuttgart. Its nature and preparation have not been closely described, but it is probably identical with the dye patented by Messrs. ROBERTS and DALE as 'Manchester Brown,' and produced by the action of alkaline nitrites on phenylen-diamine. Vesuvine dyes orange and light-brown shades. For use it is dissolved in tepid water and filtered. This solution dyes wool and silk at the heat of 87° or 88° C. The addition of hyposulphite of soda to the extent of one-tenth the weight of the colour is advantageous as regards wool. A variety of brilliant shades can be produced by the addition of a solution of chloride of tin neutralised with ammonia. Cotton tissues are first prepared with sumach; then worked in weak stannate of soda, wrung out, passed through water slightly acidulated with sulphuric acid, rinsed in cold water, and worked in the dye-bath.

VIGORITE. See EXPLOSIVE COMPOUNDS.

VINASSES. The treacle which results from the manufacture of beet-root sugars. When fermented and distilled it yields alcohol, and leaves as a residue a very aqueous brown liquid known as 'vinasse,' containing the greater part of the non-volatile matter found in the saccharine juice of the beet.

VIOLET-COLOURED FIRES. See PYROTECHNY.

VIOLET DYES. (VIOLET DYE, vol. iii. p. 1082.) *Naphthylamine Violets.*—A dye of a red or violet colour, one of the most important products of naphthalin, which was discovered by FARADAY in coal tar in 1820. Naphthylamine is composed of—

Carbon	83·91
Hydrogen	7·55
Nitrogen	8·54
	100·00

and has received the formula $C^{10}H^{9}N$.

It is a solid body, crystallising in colourless needles of offensive odour and a burning taste. It fuses at 50° and sublimes at 300°. In water it is almost insoluble, but it dissolves readily in alcohol and ether. It combines with the acids to form salts, which on exposure to the air or to oxidising agents take a red or violet colour.

One kind of violet resulting from the action of oxidising agents upon the salts of naphthylamine was discovered by Piria in 1851. Its constituents are unknown. The other kind is produced by the action of dehydrogenisers upon naphthylamine at the temperature of 200°. Their production generally accompanies that of naphthylamine red. Neither of these violets has yet been prepared on a large scale.

Naphthylen Diamine Violets result from the action of reducing agents upon binitronaphthalin. Troost prepares them by treating binitro-naphthalin with sulphides, cyanides, and sulpho-cyanides in presence of an alkali, which must not be allowed to act before the reducing agent. The violet bodies produced dissolve in alkalies, alkaline carbonates, and alcohol, from which they are precipitated unchanged by dilute acids.

Roussin treats binitro-naphthalin with proto-salts of tin dissolved in caustic alkali. If the heat of the water bath be applied, the reaction is complete when the temperature reaches 80°. The mixture is then thrown upon a filter, and washed as long as anything is dissolved. A violet-blue powder remains on the filter, easily soluble in alcohol and wood spirit, and capable of dyeing fast shades.

The new violet is a beautiful dye, giving very pure shades, much more blue than can be obtained with Paris violet of the bluest quality; and it preserves its special tone by artificial light. It is very soluble in boiling water, but the smallest trace of foreign matter modifies its solubility.

The raw materials employed for obtaining this and analogous colours are the aromatic diamines obtained on reducing the nitro-derivative from the acetylisation of organic bases.

Thus, taking aniline, *acetaniline* is first prepared, then *nitracetanilide* and *nitraniline*; then the nitraniline is reduced either by iron and acetic acid or by tin and hydrochloric acid.

The hydrochloric solution of *phenylen-diamine* is saturated with sulphuretted hydrogen, and we add perchloride of iron; the sulphur liberated combines in the nascent state with the base, and if the addition of the oxidiser is continued little by little the colouring matter is developed and precipitated. It is filtered, washed with slightly saline water to eliminate certain impurities, dissolved in boiling water, and allowed to cool, when it is obtained pure in splendid crystals. The following are the proportions employed: 20 grams of hydrochlorate of phenylen-diamine, water saturated with sulphuretted hydrogen 4,000 c.c., hydrochloric acid 20 grams, perchloride of iron in solution at one-tenth 500 c.c.

The solution of this colour in alcoholic soda is a splendid magenta red. Soda added to the solution of the violet gives a brown precipitate, the base of the new colouring matter.

This colouring matter has been obtained with *β-phenylen-diamine*; if we set out from *pseudo-toluodin* we obtain a violet much redder, and crystalline toluedin yields a violet red.—M. Ch. Lauth, 'New Class of Colouring Matters,' *Moniteur Scientifique du* Dr. Quesneville, August 1876.

VISCOSIMETER. Several instruments have been devised for measuring the viscosity of solutions of gum and other viscous materials, and of these the least expensive and most simple appears to be a glass funnel, the tube of which is drawn out to a fine point. Solutions of gum are made in definite proportions, and the funnel having been filled, the time that the several solutions take to run through is accurately noted, this operation being shorter or longer according to the viscosity of the solution under treatment.

M. Steilmann's *viscosimeter* consists of two hollow glass cylinders placed side by side, one of which is filled with pure water, and the other with the solution to be tested. Into each of these cylindrical glasses (which are precisely similar) metallic balls can be let down. These balls are suspended by silk threads, and move freely over pulleys; they are, however, partly counterpoised by means of weights. If the viscosity of the liquids placed in the glass cylinders be equal, the metal balls will descend with the same speed, provided of course that they are the same size and weight; but if one of the cylinders contains water and the other a solution of gum,

the ball will sink into the latter more slowly than into the former. The descent of the balls, when nearly at the bottom of the cylinder, is stopped by a peculiar mechanical arrangement. M. Stellmann's apparatus is in many respects an excellent one, but it is too complicated to be of great practical use to those who require to test several samples of gum in a short space of time.

VITRIOL BLUE. (Copper, Salts of, vol. i. p. 947.) *Sulphate of Copper*, known also as blue stone, blue vitriol, and Roman vitriol, is now generally prepared on a large scale direct from the ores. It forms large, hard, deep-blue crystals, soluble in 3 parts of cold and in ½ part of boiling water. In the dry atmosphere the crystals are apt to effloresce, losing part of the 36 per cent. of water normally present. A solution of blue vitriol saturated at 62° Fahr. stands at 36° Twad. If the crystals are exposed for some little time to a temperature slightly exceeding that of boiling water, the water of crystallisation is expelled, and there remains an anhydrous sulphate in the form of a white powder. In contact with minute traces of water this powder resumes its blue colour, and may therefore serve to detect the presence of water in alcohol, ether, &c. At full redness the sulphate of copper is decomposed, the oxide of copper remaining in the form of a black powder.

Sulphate of copper is often found to be impure. The protosulphate of iron (copperas) is capable of crystallising along with blue vitriol in a very considerable proportion without any alteration in its form and colour. To detect the presence of iron, the solution is boiled with a little nitric acid, and an excess of ammonia is then added. If any iron is present, brown flocks will remain floating in the ammoniacal solution of copper. Zinc may be detected, along with manganese, magnesia, &c., by a process with sulphuretted hydrogen. The sulphate of copper is used in resists for indigo blues.

Copper salts have, within the last few years, met with a new application in dyeing and printing aniline blacks, the sulphide being preferred by many.

The presence of copper, however, where not specially required, should be carefully avoided. The action of copper is generally injurious; and even in minute traces it is capable of modifying shades in an unexpected and puzzling manner. With madder it proves completely fatal, even in small quantities. A piece of sulphate of copper put into an indigo vat throws it out of order, by oxidising the white indigo and sending it, in an insoluble state, to the bottom.

VOLTAIC BATTERY. Mr. Warren De la Rue and Mr. Hugo Müller constructed a battery thus: Each element is formed of a glass tube, enclosing a rod of amalgamated zinc, 8 or 10 centimètres long and 0·48 centimètre in diameter. The bottom of the tube contains 14·50 grams of chloride of silver, well rammed down, into which runs a silver wire in communication with the zinc of the next cell. The cells are charged with a 2·3 per cent. solution of chloride of ammonium. The current from 3·240 cells traverses with a brilliant light most of the capillary tubes used in spectral analysis. It passes easily between poles 81 centimètres apart when the tube has a diameter of 3·54 centimètres.—*Comptes Rendus*, lxxxi. *Journal of Chemical Society* for March, 1876.

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WALL-PAPERS. (Paper Hangings, vol. iii. p. 477.) It has been frequently stated that green wall-papers are dangerous on account of the arsenic in the colour. This is, however, very doubtful, especially when the paper is properly manufactured. To the dangers appertaining to green must now be added, according to an article in the *Gazette des Hôpitaux*, a fresh series of poisons, which have been traced to wall-papers and materials dyed red with *coralline* dye. It was believed for some time that this material, which was used to dye stockings, socks, and other woollen goods a magnificent red, was poisonous. A young man who wore red socks, having been attacked by a very acute and painful vesicular eruption on both feet, M. Tardieu attributed this affection to the red colour of the coralline dye. The substance in question having been separated by M. Roussin, the chemist, and injected under the skin of a dog, a rabbit, and a frog, which died from its effects, it was concluded to be a violent poison and subsequently fell out of use as a dyeing agent. Contradictions were soon forthcoming; M. Landrin, a veterinary surgeon, asserted that he had administered coralline to dogs and cats without observing any subsequent ill effect. He had had positive proof of the absorption of the coralline and of its purity, since he had been able to collect it in the lungs of the animals, and to dye silk with it.

Dr. Guyot confirmed these experiments, and came to the conclusion that coralline was not poisonous, even in large doses, and that it may be safely used in dyeing, provided that it be not mixed with poisonous substances.

M. Bouchardat states that he had often had an idea that signs of poisoning by local applications of Scheele's green, or arseniate of copper were present in some cases from the nature of the symptoms recorded; but this was an *à priori* explanation which was far from convincing. Dr. Bidon, a physician of Quimperlé, states that he had an apartment hung with *fruits Passy*, a wall-paper with a red pattern on a hazel-brown (*solaetis*) ground. Whenever he inhabited this room he was annoyed by prickings of the eyelids, with itching and burning sensations; he was even attacked by purulent conjunctivitis after having slept for several nights in this room. He had the paper analysed, and, from a piece of 10 square centimètres (0·12 square yard), MM. Mayer and Lemaince obtained, with Marsh's apparatus, enough arsenical patches to cover a saucer. They were also able to extract from a larger quantity of this paper enough coralline to submit it to reagents, to dye silk and wool with it, and to obtain sufficient arsenical patches to enable them to affirm that the red substance employed to colour the paper was undoubtedly coralline, and that, in its use as a dye for paper, it was an arsenical substance, as M. Bouchardat had supposed, though M. Roussin had not been able to recognise it as such. M. Mayer could not obtain any patches of arsenic by submitting the brown portions of the paper to the action of Marsh's apparatus, and therefore came to the decision that the arsenic was only mixed with the red colour of the paper, that is, with the coralline dye.

From this it results that pure coralline is not poisonous, and may be employed as a dye; but, in materials as well as in wall-papers, an arsenical mordant is often used to fix it. This mordant, then, acts as a poison, whether acting topically on the skin, where it is directly deposited, through the medium of red shirts, drawers, and stockings, or by the dust and vapours which disengage themselves from the papers or stuffs dyed with it. We give these statements to guard people from running any risk, but we are disposed to believe that the statements made of poisonings by arsenic, coralline, picric acid, and similar agents are greatly exaggerated.

WASHING COAL. See Coal, Washing.

WATER. (Vol. iii. p. 1094.) In the article referred to, the analyses have been given of the waters of the Thames, the Exe, the Dee, the Rhine, the Danube, and the Seine. From these analyses it will be seen that the solid matter held in solution differs considerably in waters from different sources. We find for example the water from the Thames at Battersea gives 15·10 of carbonate of lime, while that from the Exe gives only 1·28, but we also see that the organic matter differs but slightly in the waters examined. Indeed, the difference is so slight that we suspect an error on the part of the chemist making the analysis.

The organic matter entering into a river has been regarded as the contaminating agent, and to it we have been in the habit of referring several forms of disease. The Commissioners on the Pollution of Rivers (from whose Reports we shall frequently quote), say, referring to the drainage areas of the Weaver and of the Irwell, that the population of the Irwell valley has increased to four times that which was found in the same district in 1801. They then continue:—

'These considerations embrace indeed within their limits the whole of the problem with which we have to deal. A certain quantity of water falls upon a given area, and upon that area circumstances have congregated a large and rapidly increasing population. But the natural supply of water is a fixed quantity; and our problem may therefore be thus stated: By what means can the largest regular supply of water be secured? and how can this supply be maintained in such a state of purity as will admit of its reiterated employment for manufacturing and other purposes, till it finds its way at last into the estuaries or into the sea in such a condition as to be neither injurious nor offensive to those living on its course or near its outfall?' Thus, we are instructed, a very large number of our rivers flowing by large towns are polluted, and the question arises, Has nature furnished any process of self-purification? To this the Commissioners reply:—

'Of the different kinds of pollution affecting rivers, animal organic matter, as it occurs in sewage, is that which renders water not only most offensive to the senses, but most likely to injure the health, both by its gaseous emanations and by its deleterious effects when used as a beverage. Rivers so polluted frequently contain from 1 to 2 lb. of organic matter, and from ¼ lb. to ¾ lb. of organic nitrogen in 100,000 lb.' It has been asserted (*Report of Royal Commission on Water Supply*, p. lxxix.), that if sewage be mixed with 20 times its volume of water, the organic matter which it contains will be oxidised and completely disappear while the river is flowing a dozen miles or so.

To this the Rivers' Pollution Commission reply:—

'So far from sewage mixed with 20 times its volume of water being oxidised during a flow of 10 or 12 miles, scarcely two-thirds of it would be so destroyed in a flow of 168 miles, at the rate of 1 mile per hour, or after the lapse of a week. But even this is arrived at by a series of assumptions which are all greatly in favour of the efficiency of the oxidising process. Thus, for instance, it is assumed that the 62·3 per cent. of sewage is thoroughly oxidised and converted into inoffensive inorganic matter; but the experiments showed that, in fact, no sewage whatever was so converted and destroyed, even after the lapse of a week, since the amount of carbonic acid in the water remained constant during the whole period of the experiment, whilst, if the sewage had been converted into inorganic compounds, the carbonic acid, as one of these compounds, must have increased in quantity.

'Thus, whether we examine the organic pollution of a river at different points of its flow, or the rate of disappearance of the organic matter of the sewage, when the latter is mixed with fresh water and violently agitated in contact with air, or finally the rate at which dissolved oxygen disappears in water polluted with 5 per cent. of sewage, we are led in each case to the inevitable conclusion that the oxidation of the organic matter in sewage proceeds with extreme slowness, even when the sewage is mixed with a large volume of unpolluted water, and that it is impossible to say how far such water must flow before the sewage matter becomes thoroughly oxidised. It will be safe to infer, however, from the above results, that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation.'—(Vol. i. p. 21.)

It was first pointed out by Professor Hoffman and Mr. Witt, that a certain quantity of even the soluble salts was separated from the water by the ordinary sand filtration. They thus describe their results:—

'These experiments upon the filtration of sewage through various materials leave no doubt that this liquid can be effectually purified by such processes, and that probably any variety of porous and finely divided soil may be employed for this purpose. Our experiments appear to show that if the soil be not overdosed with sewage it will retain its efficiency for a long, if not for an unlimited period of time, and its pores will not become clogged up.'

It is evidently proved that water containing organic matter in solution is purified by filtration through porous soil. Oxygen in its ordinary state, or in its active condition, enters into rapid combination with the organic matter, and carbonic acid is formed, or a process of nitrification is established. On this latter point Mr. R. Warington read before the Chemical Society, on December 6, 1877, a paper 'On Nitrification: a Report of Experiments conducted in the Rothamsted Laboratory.' In this he says:—

'It has been generally assumed, when such bodies decay in a porous medium offering a sufficiently large surface for oxidation, that nitrates must necessarily be formed; this view has, however, never been confirmed by exact experiments. In February last Schlœsing and Müntz (*Comptes Rendus*, lxxxiv. 301) laid before the French Academy a paper proving, in their opinion, that nitrification was due to the action of an organised ferment. Their fundamental experiment is the following: A glass tube 1 mètre long was filled with a mixture of 5 kilos. of ignited sand and 100 grams of powdered limestone. Through this mixture a slow stream of sewage filtered, so that it occupied 8 days in passing down the tube. During the first 20 days no nitrates appear in the exit water; after this period they could be detected; the quantity rapidly increased until no ammonia could be found in the exit water; this continued for 4 months. A small vessel of chloroform was now placed on the top of the tube, so that the vapour passed down through the soil (this reagent effectually suspends the action of organised ferments, *Comptes Rendus*, lxxx. 1250). In 10 days all nitrates disappeared, and the ammonia salts passed through unchanged. After 15 days the chloroform was withdrawn, but no nitrification took place during 7 weeks: 10 grams of a soil which was known to nitrify were now treated with water, and the washings poured on the column of sand, so as, if possible, to seed the soil anew; 8 days after nitrates again appeared as before. The importance of this new theory is clearly very great, so the author has tested it by further experiments in two distinct lines of proof: The action of antiseptic vapours in preventing nitrification. Four tubes were filled with moist kitchen-garden soil; through the first moist ammonia free air was drawn by an aspirator; through the second moist air as before, but it was passed through a bottle containing sponge moistened with carbolic acid. The air drawn through the third tube was similarly charged with a little bisulphide of carbon; that through the fourth with chloroform. Two series of experiments were made. At the end of the experiments the nitrates formed in the soil were determined by the method of Crum and Frankland; the results are given in the following table, the experiments lasting 39 and 46 days respectively:—

Nitrogen as Nitrates and Nitrites per million of Air-dried Soil.

History of Soil	First Experiment	Second Experiment
Original soil	6·12	8·91
Air passed	40·87	50·86
Air passed with carbolic acid	17·20	40·77
Air passed with carbon bisulphide	6·70	9·75
Air passed with chloroform	9·48	7·86

It becomes important, after these statements, to examine the composition of several kinds of waters. The waters supplied by the London Water Companies have been selected, bearing as they do upon the important question of the future water supply of the metropolis. The condition of the water obtained from Kent deserves special attention. The following tables given by the Rivers' Pollution Commissioners may be regarded as the most satisfactory examination which has been made :—

Metropolitan Waters.

(These Waters were all collected during the month of October 1877.)

Sources from which obtained	Total Solid Matters	Organic Carbon	Organic Nitrogen	Nitrogen as Nitrites and Nitrates	Total combined Nitrogen	Chlorine	Total Hardness
Chelsea	25·96	·112	·025	·158	·183	1·60	17·7
West Middlesex	27·80	·078	·017	·175	·192	1·50	20·1
Southwark and Vauxhall	27·32	·087	·027	·210	·257	1·52	19·7
Grand Junction	28·04	·067	·018	·210	·257	1·52	20·7
Lambeth	26·38	·091	·015	·256	·271	1·55	20·4
New River	26·40	·080	·011	·251	·262	1·60	20·3
East London	27·64	·055	·017	·161	·178	1·80	20·9
Kent	42·24	·060	·008	·573	·581	2·60	26·6

The above should be read thus :—The Chelsea water was collected October 11, 1877; and 100,000 lb. of it contained 25·96 lb. of solid matter. The organic substances, constituting a portion of this solid matter, contained ·112 lb. of carbon, and ·025 lb. of nitrogen. This water contained no ammonia, and ·158 lb. of nitrogen in the form of nitrates and nitrites, whilst the amount of combined nitrogen in every form was ·183 lb. The above weight of water also contained 1·60 lb. of chlorine (existing as chlorides?), and 17·7 lb. of carbonate of lime, or an equivalent quantity of other hardening or soap-destroying ingredients. This applies equally to each of the other waters.

The Means of a Year.

	Solid Matters	Organic Carbon	Organic Nitrogen	Nitrogen as Nitrites and Nitrates	Combined Nitrogen	Chlorine	Hardness; Carbonate of Lime
Chelsea	27·32	·197	·034	·225	·259	1·93	20·8
West Middlesex	27·04	·173	·028	·201	·230	1·88	20·0
Southwark	27·19	·180	·030	·200	·231	1·86	20·3
Grand Junction	27·31	·183	·032	·207	·239	1·86	21·2
Lambeth	28·47	·206	·040	·246	·287	1·90	21·4
New River	28·10	·107	·018	·248	·266	1·72	22·1
East London	29·45	·175	·035	·169	·205	1·97	21·3
Kent	41·22	·050	·010	·461	·471	2·54	29·9

Average Composition of Unpolluted Water. Results of Analyses expressed in parts per 100,000.

Description	Dissolved Matters											
	Total solid Impurity	Organic Carbon	Organic Nitrogen	Ammonia	Nitrogen as Nitrates and Nitrites	Total combined Nitrogen	Previous Sewage or Animal contamination	Chlorine	Hardness: Temporary	Hardness: Permanent	Hardness: Total	No. of Samples analysed
Class I. Rain water	2·95	·070	·015	·029	·003	·042	42	·22	·4	·5	·3	39
Class II. Upland surface water	9·67	·322	·032	·002	·009	·042	10	1·13	1·5	4·3	5·4	195
Class V. Deep well water	43·78	·061	·018	·012	·495	·522	4,743	5·11	15·8	9·2	25·0	157
Class VI. Spring water	28·20	·056	·013	·001	·383	·390	3,559	2·49	11·0	7·5	18·5	198

Note.—For the conversion of above numbers into grains per Imperial gallon, multiply them by 7, and move the decimal point one place to the left.

Average Composition of Unpolluted Deep Well Waters.

Description	Total solid Impurity	Organic Carbon	Organic Nitrogen	Ammonia	Nitrogen as Nitrates and Nitrites	Total combined Nitrogen	Previous Sewage or Animal contamination	Chlorine	Hardness: Temporary	Hardness: Permanent	Hardness: Total	No. of Samples analysed
Deep wells in Devonian rocks, and millstone grit	32·08	·069	·012	·006	·234	·310	2,671	2·70	8·8	8·6	17·4	7
Deep wells in the coal measures	53·10	·119	·034	·014	·207	·278	2,243	18·05	15·1	20·6	35·7	9
Deep well water from magnesian limestone	61·14	·076	·030	—	1·426	1·456	13,937	4·31	16·9	26·9	43·8	8
Deep wells in New Red sandstone	30·63	·036	·014	·003	·717	·734	6,895	2·04	7·4	10·5	17·9	29
Deep wells in the lias	70·98	·146	·027	·001	·389	·417	3,730	4·42	21·9	8·2	30·1	2
Deep wells in the oolites	33·60	·037	·010	·022	·025	·054	6,118	2·09	13·8	6·8	20·6	5
Deep wells in Hastings sand, the lower and upper greensand, and Weald clay	45·20	·068	·014	·010	·196	·223	1,864	5·38	16·8	10·5	27·3	20
Deep wells in the chalk	36·68	·050	·017	·001	·610	·628	5,801	2·76	21·2	6·5	27·7	60
Deep wells in the chalk beneath London clay	78·09	·093	·028	·048	·098	·135	707	15·02	9·7	8·7	18·4	13
Deep wells in Thanet sand and drift	53·81	·113	·020	·072	·116	·202	1,617	6·32	14·4	7·6	22·0	4
Average of above ten analyses	52·01	·080	·020	·021	·404	·508	4,557	6·46	14·6	11·4	26·0	—

Note.—The samples of water belonging to this division were obtained from wells, or boreholes, of a depth rarely less than 100 feet, and reaching in one case as far as 1,393 feet.

Professor Frankland writes: 'Careful observations made by us have demonstrated that in the river water supplied to London the soluble organic matters, and some of the suspended matters of sewage and manure, reach the water-drinker in a few hours, and in substantially the same condition in which they leave the sewers and fields; but the organic matter present in deep wells, although it may have had the same origin, has been subjected to the powerful oxidising influence of porous chalk for a period of many months, if not of years, before it is raised to the surface and distributed.'

The Results of Analyses, expressed in parts per 100,000, of Deep Well and Spring Water at the New River Company's Works.

	Total Solid Matter	Organic Carbon	Organic Nitrogen	Nitrogen as Nitrates, &c.	Chlorine	Hardness	
Amwell Well (May) .	31·36	·076	·009	·406	1·39	22·4	Clear and colourless
,, ,, (July) .	33·56	·161	·055	·432	1·85	23·9	Turbid
Cheshunt . . .	23·05	·863	·165	—	1·00	10·6	Very turbid
New River, after subsidence and filtration . . .	22·00	·227	·043	·186	1·65	16·6	Clear
New River Head after filtration . .	31·56	·242	·043	·334	1·70	23·6	Turbid
Chadwell Spring .	29·80	·420	·084	·381	1·50	20·0	Very turbid

The following table collates the particulars obtained by the Rivers' Pollution Commission:—

Name of Company	Area of District	Number of Houses	Number of Factories	Volume of Daily Supply	Area of Subsidence Reservoirs	Area of Filter Beds	Rate of Filtration per Hour
	Sq. miles			Gallons	Acres	Acres	Inches
Lambeth . . .	60	42,000	1,000	12,000,000	—	2¼	10
Southwark and Vauxhall . . .	—	70,000	600	17,000,000	12	14½	4
Grand Junction .	—	24,243	140	12,290,221	7	7½	3
West Middlesex . .	12	41,000		9,844,000	20	4½	4
Chelsea . . .	8	28,279		10,000,000	—	9½	6
Kent	60	42,000	900	9,000,000	—	—	—
New River . . .	22	190,242	900	21,865,000	100	11¼	4·1
East London . .	7	102,067	5,000	21,000,000	220	38	3

The following returns were made by Dr. Letheby to the Society of Medical Officers of Health of the average composition of the metropolitan waters:—

Names of Water Companies	Total Solid Matter per Gallon	Oxygen required by Organic Matter, &c.	Nitrogen		Hardness	
			As Nitrates, &c.	As Ammonia	Before Boiling	After Boiling
Thames water companies—	Grains	Grains	Grains	Grains		
Grand Junction . .	19·78	0·034	0·146	0·002	14·9	3·8
West Middlesex . .	19·32	0·044	0·146	—	14·6	3·6
Southwark and Vauxhall	19·80	0·032	0·151	0·002	14·8	3·8
Chelsea	19·59	0·077	0·142	0·001	14·8	3·8
Lambeth . . .	19·78	0·055	0·150	0·001	14·8	3·8
Other companies—						
Kent	28·03	0·007	0·304	—	20·9	5·9
New River . . .	19·06	0·030	0·147	—	14·5	3·4
East London . . .	20·70	0·046	0·172	0·001	15·1	3·9

NOTE.—The amount of oxygen required to oxidise the organic matter, nitrites, &c., is determined by a standard solution of permanganate of potash acting for three hours; and in the case of the metropolitan waters the quantity of organic matter is about eight times the amount of oxygen required by it.

The water was found to be clear and nearly colourless in all cases but the following, when it was slightly turbid—namely, in the case of all the Thames companies, excepting the WEST MIDDLESEX.

The following results are the averages of the analyses of the samples of water taken monthly from the mains of the several companies during the year, and they show that the total proportions of solid matter dissolved in the water have been as follows—namely, 19·67 grains per gallon of the Thames supply, 19·09 grains of the New River supply, 20·7 grains of the East London supply, which is chiefly from the Lea, and 28·02 grains per gallon of the KENT COMPANY'S water, which is obtained from deep wells in the chalk. The solid matter consists in all cases of a very large proportion (about two-thirds of the whole) of carbonate of lime, with a little carbonate of magnesia, and the other third is composed in nearly equal parts of sulphate of lime, common salt, and nitrate of magnesia. These substances, in the proportion in which they exist in the metropolitan supply, are of prime importance in a dietetical and sanitary point of view, for experience has shown that waters of a moderate degree of hardness from the presence of calcareous salts are more wholesome than those which are deficient of such substances. It is satisfactory to know that the water supplied to the metropolis is remarkably free from organic pollution; the nitrogen, for example, which is present as actual or saline ammonia does not exceed the $\frac{1}{1000}$th part of a grain per gallon of water, and in several cases, as in the KENT, the NEW RIVER, and the WEST MIDDLESEX COMPANIES' water, it is entirely absent. So also with regard to organic or albuminoid nitrogen the proportion is exceedingly small, averaging in the case of the KENT COMPANY'S water the 0·002 of a grain per gallon; in the WEST MIDDLESEX and NEW RIVER COMPANIES' water the 0·004 of a grain; in the East London water, the 0·006 of a grain; and in the rest of the companies the 0·007 of a grain. Nitrogen as nitrates ranges from 0·147 of a grain per gallon of the water derived from the Thames, to 0·306 of a grain in the deep well waters from the chalk. All these facts, together with the small proportion of alkaline chloride in the water, indicate a remarkable freedom from sewage or other organic pollution, and they fully sustain the high opinion entertained of the wholesome quality of the water supplied to London, as expressed in the reports of the Scientific Commission of 1850, the Select Committee of the House of Commons of 1867, and the Royal Commission on Water Supply in 1869, all of whom were specially appointed to investigate the quality of the water supplied to the metropolis.

The quantity of water daily supplied to the metropolis has ranged from 31·9 gallons per head of the population to 36·9 gallons—the average for the whole year being 33·7 gallons per head per diem. Month by month the proportions have been as follows:—

1873	Gallons per Diem	Houses supplied	Gallons per Head daily
January . . .	108,399,776	515,292	31·9
February . . .	109,627,033	515,346	32·2
March . . .	109,352,343	516,514	32·2
April	112,045,907	517,200	32·8
May	121,543,736	517,489	35·3
June	127,381,916	518,127	36·9
July	122,319,058	519,063	35·5
August . . .	125,186,742	519,669	36·3
September . . .	117,744,857	521,068	34·2
October . . .	117,744,907	521,068	34·2
November . . .	109,998,771	521,300	31·9
December . . .	111,420,540	521,566	32·3
Average . .	116,155,787	518,600	33·7

About half of the water is derived from the Thames, about a third from the New River and the Lea, and the rest from deep wells in the chalk. The largest proportion of it—amounting to about 90 per cent.—is used for domestic purposes; and, considering the requirements of a household, a daily supply of 26·5 gallons per head of

the population, or about 160 gallons per house, is abundantly sufficient for all domestic and sanitary purposes.

The Rivers' Pollution Commission state that there is abundance of water in the Thames basin to supply, for many years to come, all that may be required by the increasing population of the metropolis.

(All the estimates which have been made by the Royal Commission, by the Rivers' Pollution Commission, and by the Metropolitan Board of Works, are founded upon the hypothesis that the increase of population is to proceed at the rate which has been maintained for the last few years. We have only the *metropolitan* area to deal with, but the rate of increase which has been estimated for Great Britain has a strict relation to the increase of people in the metropolis, therefore we give an abstract from the estimate made for the Royal Coal Commission by Mr. Price Williams. In 1871 the population of Great Britain was 26,062,721. In 1971 it is estimated to increase to 58,928,000. In 2071 to 93,000,000, and so on. In 1877 (June) the population of the United Kingdom, as estimated by the Registrar-General, was 33,444,419; the population of London to same date, June 1877, being 3,533,484 people.)

It has in every case been forgotten to examine the great natural checks to this rapidly-increasing rate. That for some years to come the increase will be maintained appears to be tolerably certain, but, notwithstanding everything that has been effected in the way of sanitary improvements, it will, we believe, be found that the necessities of our existence will be the means of establishing strong checks upon the increase of the number of inhabitants in the metropolis. We are disposed to believe that the probability is, that the metropolitan population will receive such natural checks that it will never far exceed—within the district of Greater London—4,000,000 of souls.

In vol. iii. p. 1100, the purification of water by filtration has been already dealt with, and the use of Mr. Spencer's process of purifying water by the employment of magnetic oxide of iron is described. At page 367 of this volume the spongy iron filter is noticed. Of this filter an extended experience has served to prove its real value as a purifier of water for drinking purposes. The following additional particulars may now be given. These are derived from the report of the Royal Commission:—

'Filtration on the large scale is rarely performed with uniform efficiency, and the water delivered in towns is, therefore, frequently submitted to domestic filtration through sand and other materials. Filtration upon a small scale may, if carefully performed, be rendered much more efficient than the waterworks' process as at present most frequently conducted; but we are bound to say that domestic filtration, when left to the care of average servants, not only entirely fails to purify the water, but actually often renders it more impure than before. No other result than this can be expected if we consider the work which the domestic filter is called upon to do. A small volume of the filtering material is crammed into the smallest possible space, and then for months, or even years, water, more or less polluted, is passed through it until the pores become so clogged with filth as to refuse the transmission of more liquid. Long before this happens, however, the accumulation of putrescent organic matter, upon and within the filtering material, furnishes a favourable nest for the development of minute worms and other disgusting organisms, which not unfrequently pervade the filtered water, whilst the proportion of organic matter in the effluent water is often considerably greater than present before filtration. . . .

'Of all materials for domestic filtration with which we have experimented, we find animal charcoal and spongy iron to be the most effective in the removal of organic matter from the water. We are not prepared to say that these are the only materials in actual use which are efficient; they are, however, the only successful ones amongst those with which we have had the opportunity of making satisfactory trials. . . .

'The removal of mineral constituents, and the consequent softening of the water (by animal charcoal), ceases in about a fortnight, but the withdrawal of organic matter still continues, though to a greatly diminished extent, when the filter is much used, even after the lapse of six months.

'The property, which animal charcoal possesses in a high degree, of favouring the growth of the low forms of organic life, is a serious drawback to its use as a filtering medium for potable waters. . . .

'We have obtained still more remarkable results by continuous filtration of water through metallic iron, which had been prepared by the reduction of hematite ore at the lowest practicable temperature. . . .

'The iron thus obtained, not having been melted as in the ordinary smelting furnace, is in a finely divided and spongy condition, and appears to be a very active agent, not only in removing organic matter from water, but also in materially reducing its hardness and otherwise altering its character when the water is filtered through

the "spongy material. The following table contains the results of analyses of many pairs of samples, one of each pair being the water delivered by the CHELSEA COMPANY at the laboratory in Victoria Street, Westminster; and the other, the same water, after filtration through spongy iron, which was supplied to us by Mr. GUSTAV BISCHOF, formerly Professor of Technical Chemistry in the Andersonian University of Glasgow, the discoverer of the remarkable properties possessed by "spongy iron" in reference to the purification of potable water.'

A selection from that table is made. The results of analyses are expressed in parts per 100,000:—

Time when the Water was taken from the Thames		Organic Carbon	Organic Nitrogen	Previous Sewage Contamination
January 24.	Before filtration .	·209	·045	1·820
"	After " .	·120	·031	·300
February 24.	Before " .	·200	·031	1·430
"	After " .	·060	·018	·540
March 25.	Before " .	·175	·026	1·560
"	After " .	·077	·021	—
April 23.	Before " .	·197	·028	1·090
"	After " .	·073	·013	—
May 21.	Before " .	·188	·034	·890
"	After " .	·059	·020	—
September 15.	Before " .	·120	·015	1·340
"	After " .	·025	—	·010
October 15.	Before " .	·160	·072	1·970
"	After " .	·046	·015	—
November 27.	Before " .	·230	·047	2·050
"	After " .	·060	·008	1·200

'The numbers in this table show in every case a most satisfactory reduction of the proportion of organic matter (organic carbon and organic nitrogen), and of the hardening constituents, the hardness being often reduced by about 50 per cent., and this after the filter had been in constant action for upwards of eight months. . . .

'Under the influence of this material Thames water assumes the character of a deep well water.'

The editor of this volume has had both Mr. SPENCER'S filter and that of Professor BISCHOFF for more than a year in action, and nothing can be more satisfactory than the results, the magnetic oxide of iron removing very decidedly all trace of organic matter.

The value of filtration through charcoal and through sand are shown by the experiments made by Dr. HOFMANN and Mr. WITT, as published in the Report on Metropolitan Drainage.

The experiments on filtration through charcoal were made with peat charcoal furnished by Mr. JASPER ROGERS.

Effects of Charcoal Filtration after Two Hours.

	Total Solid Constituents originally present	Amount present in Filtered Liquid	Amount separated
	Grains per Gallon	Grains per Gallon	Grains per Gallon
Mineral matter . . .	77·56	48·31	29·25
Organic matter . . .	63·55	12·57	50·98
After Four Hours.			
Mineral matter . . .	77·56	63·77	13·79
Organic matter . . .	63·55	34·76	28·79

After this filtration continued for four hours no less than 14·31 grains of suspended matter passed through, showing that charcoal after only a few hours loses its power of separating the dissolved matter.

Effects of Sand Filtration for Two Hours.

	Total Solid Constituents originally present	Amount present in the Filtered Liquid	Amount separated
	Grains per Gallon	Grains per Gallon	Grains per Gallon
Mineral matter	77·56	51·14	26·42
Organic matter	63·55	32·11	31·44

In the case of the filtration through charcoal, the amount of dissolved matter removed was obvious, since the filtered liquid was perfectly clear and free from suspended matter; but in this case the whole of the suspended matter was never removed, and it therefore became necessary to determine the proportion of suspended to dissolved matter in the filtered liquid, in order to bring out this interesting point.

Comparison of the composition of the sewage before and after filtration through sand for two hours to show the proportion of suspended and dissolved matter in the filtered liquid, in order to bring out this interesting point:—

	Composition before Filtration	Composition of Filtered Liquid	Amount separated
FOR TWO HOURS.			
Suspended Matter—	Grains per Gallon	Grains per Gallon	Grains per Gallon
Mineral	21·48	0·66	20·82
Organic	35·42	1·62	33·80
Total . . .	56·90	2·28	54·62
Dissolved Matter—			
Mineral	56·09	50·48	5·610
Organic	28·13	30·49	nil [1]
Total . . .	84·22	80·69	—
Total—			
Mineral	77·57	51·14	26·43
Organic	63·55	32·12	31·24
	141·12	83·25	57·67
FOR FOUR HOURS.			
Mineral	77·57	58·29	19·28
Organic	63·55	32·18	31·37
	141·12	90·47	50·65

It is evident from these experiments that charcoal is, at first, more active than sand in separating the organic and mineral matter from the water filtered through it, but that it rapidly loses this property, which, however, it acquires again upon being properly reburnt. It is satisfactorily made out that filter beds of sand, being properly constructed, will remove from water a very large portion of both the organic and mineral matter, but that after a certain period they lose their power of separating them. This depends evidently upon the filling of the interstitial spaces between the grains of sand with the organic matter separated. All the evidence goes to show that a properly prepared filter bed will render the Thames water an excellent drinking water, but that those beds, however carefully made, will lose their power after a time—*this time has to be determined*—and require careful renewal.

[1] In fact, some little amount of the organic matter which had been previously removed from solution was released from its state of combination with the sand, probably by the superior attraction for the suspended or mineral matter presented to it in the latter stages of the experiment.

WATERS, MINERAL. (Vol. iii. p. 1066.) The following analyses of mineral waters are given as examples of the extremely complex character of some of the more remarkable mineral springs:—

The Chalybeate Springs of St. Moritz, in the Upper Engadine.

In 10·000 grams of water M. August Husemann found—

	Old Well	New Well
Chlorine	0·27255	0·21778
Bromine	0·00417	0·00077
Iodine	0·00011	0·00002
Fluorine	0·00255	0·00787
Sulphuric acid	1·79706	1·57698
Boracic "	0·01913	0·03771
Nitric "	0·00211	0·00459
Phosphoric "	0·00156	0·00144
Silicic "	0·40169	0·53445
Carbonic "	34·02031	35·96061
Potash	0·07778	0·08001
Soda	2·72441	2·37615
Lithia	0·00299	0·00312
Ammonia	0·01056	0·00946
Lime	4·77134	5·06314
Strontia	0·00062	0·00065
Magnesia	0·61603	0·63184
Protox. manganese	0·02366	0·02499
" iron	0·14694	0·17392
Hydro-oxide iron	—	0·06108
Alumina	0·00050	0·00030
Baryta, &c.	traces	traces
Specific gravity	1·002235	1·002325
Temperature in July	5·42°	5·23°

Composition of the Mineral Spring on the Left Bank of the Inn at Tarasp, in the Lower Engadine.—(These springs originate in a calcareous clay slate rich in iron pyrites):—

The 'Bear' Spring (Ursusquelle).

(The carbonates calculated as mono-carbonates.)

		In 10,000 Grams of Water
Chloride of lithium	0·0624	grams
" sodium	28·6734	"
Bromide of "	0·1956	"
Iodide of "	0·0032	"
Sulphate of potassium	2·7717	"
" sodium	16·7109	"
Borate of sodium	2·4107	"
Nitrate "	0·0053	"
Mono-carbonate of sodium	23·9004	"
" " ammonium	0·3092	"
" " calcium	16·8025	"
" " magnesium	5·7825	"
" " strontium	0·0030	"
" " iron	0·1298	"
" " manganese	0·0019	"
Silicic acid	0·1025	"
Phosphoric acid	0·0030	"
Alumina	0·0025	"
Barium, &c., and organic matter	traces	
Total solid constituents	98·1460	

'The New Bath Spring (*Badequelle*) contains only 30·7906 solid constituents.

'The New Spring (*Irenquelle*) only 28·0099 solid constituents.'—Aug. Husemann, *Arch. Pharm.*, 3.

Canada.—At Goderich, Paris, St. Catherine's, Pakenham, Caledonia Springs, and other places in Ontario, Canada, mineral waters are obtained.

The following analyses of these different waters were made many years ago by Dr. T. S. Hunt:—

	Caledonia Gas Spring	Saline Spring	Sulphur Spring
Chloride of sodium	6·0675	6·4409	3·5430
" potassium	·0309	·0296	·0230
Bromide of sodium	·0150	·0169	·0100
Iodide "	·0005	·0014	traces
Sulphate of potash	·0053	·0048	·0183
Carbonate of soda	·0485	·1762	·4558
" lime	·1480	·1175	·2100
" magnesia	·5262	·5172	·2940
" iron	traces	traces	traces
Alumina	·0044	undet.	·0026
Silica	·0310	·0425	·0840
In 1,000 parts water	7·7773	7·3470	4·9407
Specific gravity	1006·2	1005·8	1003·7

WATERPROOFING. A method of waterproofing fabrics by means of a bath of paraffin was patented in this country by M. C. CLAMOND, of Paris (December 2, 1876). It is said to yield good results.

M. CLAMOND has invented special apparatus for carrying out the process, which is thus described: The fabric passes from the roller containing it through a bath of dissolved paraffin, and at its exit is pressed between two rollers, which remove excess of liquid. It then enters a chamber heated by coils of steam pipes, and passes up and down over a series of rollers until it reaches the exit, where it is received in any suitable manner. Attached to this chamber is another, containing a series of vertical pipes or diaphragms, between which cold water is kept continually circulating. As the cloth passes over the series of rollers in the first chamber the naphtha, bisulphide of carbon, or other solvent of the paraffin, is driven off by the heat of the steam coils; and the vapours pass from the first chamber into the second, where they are condensed by coming into contact with the cool surfaces of the water coils or diaphragms, and fall down into a receiver at the bottom, whence they are removed for use again. Such portions, however, as are not condensed re-enter the first or evaporating chamber again, and pass through the same round until they are condensed. By this means there is practically but little loss of the volatile ingredient of the waterproofing solution. See CAOUTCHOUC, vol. i. p. 183.

M. DUJARDIN gives the following:—About 1 lb. Troy of potash, alum, and sugar of lead, are triturated in a mortar until the mass becomes syrupy, and then about 14 Troy ozs. of finely-powdered mixture of bicarbonate of potash and sulphate of soda in equal parts should be added. To this mixture there should now be given about 11 gallons of rain water, and when complete solution is effected the same is to be poured into a vessel containing an oleine soap in solution in an equal quantity of water. This mixture is to be stirred for about twenty minutes, or until complete mixture has occurred. To waterproof a fabric it is necessary only to immerse it in this solution with the hand or by mechanical means, and to retain it there until by pressure or otherwise the fluid has penetrated to every portion of it. The fabric is then removed and, after allowing the surplus fluid it retains to drop off, hung up to dry. Afterwards it is thoroughly washed in cold water, and again dried. Goods treated in this way, it is affirmed, are waterproof, but still permit free transmission of air; the colours of the goods being in no wise affected.

This is given on the high authority of M. DUJARDIN, but we are disposed to doubt if a clear solution can be obtained. A more common method of waterproofing is to use separate solutions of acetate of lead and alum, so that by the decomposition which takes place in the fabric both alumina and oxide of lead are precipitated within it.

WAVELLITE. This mineral has been found in this country near Barnstaple, and at Stennagwyn, near St. Austell; at Clonmel, near Cork, in Ireland, and in some islands on the coast of Scotland. Its composition is—

Phosphoric acid	33·40
Alumina	35·35
Peroxide of iron	1·25
Lime	0·50
Hydrofluoric acid	2·06
Water	26·80

See [illegible].

WAX. (Vol. iii. p. 1110.) Our importations in 1875 and 1876 were:—

	1875		1876	
	Cwt.	Value	Cwt.	Value
From Portugal	1,699	£10,685	6,558	£33,715
,, Morocco	1,621	9,842	1,386	9,227
,, China	2,976	7,781	3,079	6,686
,, Japan	8,724	20,213	12,325	24,030
,, United States of America .	3,192	25,097	3,529	22,016
,, British West Africa . .	1,764	11,400	1,145	8,444
,, Australia	708	5,071	591	4,136
,, British West Indies . .	1,216	8,061	1,290	9,645
,, other Countries . . .	3,761	20,897	3,903	26,256
	26,551	£118,549	33,896	£140,677

WEATHER CHARTS. The Director of the Meteorological Office, A. H. Scott, F.R.S., communicated to the Society of Arts an account of the construction of the weather charts which appear daily in the newspapers. From that communication, printed in the *Journal of the Society of Arts*, we collect the following:—

The production of the chart is a pretty simple matter. The observations at about fifty stations in these islands and on the Continent are taken at about 8 A.M., and telegraphed in cypher to London, where they arrive, when all goes well, before 10 o'clock. As fast as they come in the figures are put down in their proper places on a large chart, and as soon as this chart is finished, so as to afford a reasonably complete view of the general state of meteorological affairs for the day, the chart for the newspapers is commenced. The space which can be allotted to the chart in the columns of the *Times* is but small, and so it is necessary to condense into it as much information as possible without sacrificing clearness. Once the chart is drawn, it is sent to the Patent Type Founding Company's works in Red Lion Square (see p. 684 of this volume), and there copied mechanically, at a reduced scale, on a slab of a special composition, which has been formed in a mould bearing in bold relief the outline of the land on the map. This outline, of course, comes out in the impression as a deep groove. The engraving is done by a drill, the depth of the cut being regulated by the workman. The only speciality about this part of the process is that the composition cuts quite true, without risk of chipping. The curves are copied direct from the chart, while the words and letters are put on by means of templates, so as to insure uniformity in the type.

The instant the engraving is completed the slab is ready to furnish a cast, which is, in the first instance, taken in rather fusible metal, to save time in cooling. This first block being obtained, the ordinary process of taking an impression from it in paper ensues, and this being effected, it is a simple matter to produce from this impression any number of stereotype blocks type high, which are then sent to the newspaper office, set up with the type, and worked off in the usual way, just like a paragraph of letterpress.

The next point then is what this chart shows us. In the first instance we see the dotted lines: these are what are called 'isobars,' from two Greek words meaning 'equal pressure.' These lines are obtained by drawing lines on the chart to join together the places where the barometrical readings are the same, and they are the most important lines we can give on a weather chart, to show us, when their indications are read aright, what the winds and weather are likely to be. The other entries on the chart are the temperature at certain prominent stations; the state of the weather and the sea disturbance, which are given in words, the latter being always in capital letters; and, though last not least, the wind, which is shown by arrows flying *with it*, not *against it*, like the vane of a weathercock. The force of the wind is shown by five grades, which are as follows:—O calm, ⟶ light, ⟶ fresh to strong, ⟶ a gale, ⟶ a violent gale. The final result is the chart published, and it can be produced in about an hour after the completion of the original chart in the office.

With regard to the actual interpretation of the chart, the Director presupposes in his readers some knowledge of the elements of meteorology, else it would be hopeless within the limits at his disposal to render his remarks intelligible. The most important principle, of which sight must never be lost, is that of the relation of the wind, both in direction and force, to the distribution of barometrical pressure. Wind

is produced by differences of pressure, for the air naturally flows from a place where pressure is in excess to one where it is in defect, and this motion of the air is wind. The wind moves not in straight lines, but in great curves or sweeps, and its motion is ruled by the distribution of pressure, as we shall soon see. A glance at almost any of these charts will show that, even on the calmest day, there are appreciable differences between the barometrical readings taken at the same time over the United Kingdom. Meteorology is not at present able to explain what the cause of such differences of pressure are—if it were we should have made many steps towards the accurate prediction of weather—and we must for the present take these areas of high and low pressure respectively as existing, but we may assert that on the mutual action of these areas on each other all our weather, with its manifold and perplexing changes, depends. The areas are called cyclonic and anticyclonic, from the Greek word κύκλος, a circle; PIDDINGTON, the author of the *Seaman's Handbook of the Law of Storms*, having been the first to propose the generic name of 'cyclones' for the typhoons of the Eastern Seas and the hurricanes of the Atlantic, which are each connected with an area of very low pressure (*i.e.*, an area where the barometer has fallen very rapidly), round which the wind sweeps with terrific velocity. Practically, at present, any region of relatively low pressure is called cyclonic, and any region of relatively high pressure, anticyclonic. If at any place, or over any district, the barometrical reading is lower than at the places all round it, that place or district is the centre of a cyclonic area; if, on the contrary, the reading at the place or district is higher than at places all round it, that place or district is the centre of an anticyclonic area.

A chart like those now under consideration is rarely sufficient to show the full extent of an area of either class, but we can gather from the general course of the isobars, and the directions of the several winds which are shown on it, where the respective areas lie. These areas or regions, as they are also called, are shown on a chart by the course of the isobars which enclose them. On such a chart there are several isobars corresponding to the various gradations of barometrical pressure.

A stereotyped chart can be delivered to a London newspaper within about four or five hours after the observations have been taken all round our coast, but the mere cost of telegraphy for a single set of, say, twenty-five reports is 1*l*. 5*s*. a day, or about 400*l*. a year (including Sundays), and the expense of a night service of reports from such stations as are open at a late hour, with the extra attendance at the London office entailed thereby, could not be less than 1,000*l*. a year. Had the Meteorological Office that sum at its disposal for the purpose, the work could be done, but it is hardly reasonable to ask the Government to pay such an amount for the ostensible purpose of furnishing recent weather information for the public press.

It is a very favourite matter with the critics of European meteorological work to contrast the weather charts, published thrice a day at Washington, with those that are issued only once a day here. In such strictures the circumstance is always ignored that the cost of weather telegraphy in the United States is 50,000*l*. a year, exclusive of all salaries, while our own Meteorological Office can only devote to the same object an annual sum of less than 3,000*l*.

In conclusion, the Director makes a short digression with reference to the principles on which storm warnings are issued.

As soon as the telegraphic reports indicate that a disturbance of the atmosphere, probably accompanied by a gale, has either reached us or is near our shores, warning telegrams are issued to such parts of our coasts as are apparently threatened. The principles which we have to guide us in forming a judgment on these points cannot be stated briefly, but they are, in very general terms, as follows:—

The approach of a cyclonic disturbance is shown by the fall of the barometer and the changes of the winds at the different stations, in accordance with BUYS BALLOT'S Law. Corroborative evidence is afforded by the variations of temperature and of weather, by the roughness of the sea, by the appearance of haloes, auroras, &c. The coasts threatened in the first instance are usually those where these symptoms first appear. The probable subsequent path of the storm, if storm there be, is shown by the general distribution of barometrical pressure, as already explained, and by the behaviour of the barometers at our different stations as the time wears on.

The degree of success which has attended our warnings in these islands, on the average of the last two years, has been that over 45 per cent. have been followed by severe gales, and over 33 per cent. in addition have been followed by wind too strong for fishing boats or yachts, though in themselves not severe gales; this gives a total percentage of success of nearly 80.

It cannot, however, be too emphatically stated that the meteorologists who have had most experience in dealing with meteorological telegraphy in Western Europe are most decided in their opposition to any idea of their being able to foretell weather with certainty in the present condition of our knowledge.

WEIGHTS. (WEIGHTS AND MEASURES, vol. iii. p. 1119.) A question has been raised as to the variability of platinum weights in process of time. The Warden of the Standards shows, in his recent report, that the weight of the English platinum kilogram of the Standards Department was found in 1875 to be practically unchanged since it was weighed—with the greatest care and accuracy—in 1845, and that its utmost possible loss of weight in that period could not have exceeded three parts out of 10,000,000. But though the platinum standard weights have thus been found unaltered by atmospheric influences, the slight changes observed in a few exceptional cases being attributable to improper preparation of the metal, yet pure platinum is too soft a material to stand the friction of much use without losing some of its weight. This defect, it is found, may be remedied by combining with the platinum about 10 per cent. of iridium. An alloyed metal is thus produced as hard as steel, such as has been adopted for the new international standard kilogram by the Metric Commission at Paris.

WELDING COPPER. The great obstacle to effecting a weld between two pieces of copper has been the formation of oxide of copper on the surface. Mr. Rust, in a communication to the *English Mechanic*, states that he has thoroughly succeeded, and that, as long since as 1854, he welded strips of copper plate together and drew them into a rod; that he also made a chain, the links of which were of pretty thick wire and welded.

In describing his process he says:—Now, if any fusible compound of the oxide of copper could be found, it would render such a weld possible. We find in mineralogy two copper salts of phosphoric acid, viz.—libethenite and pseudo-malachite—each of which melts readily before the blowpipe. It was therefore natural to suppose that a salt which contained free phosphoric acid, or which would yield the same at a red heat, would make the weld easy by removing the oxide as a fusible slag.

The first trial was made with microcosmic salt (phosphate of soda and ammonia), and succeeded perfectly. As this salt was dear, it was found advisable to use a mixture of one part phosphate of soda and two parts boracic acid, which answered the same purpose as the original compound, with the exception that the slag formed was not quite as fusible as before.

This welding powder should be strewn on the surface of the copper at a red heat; the pieces should then be heated up to a full cherry red or yellow heat, and brought immediately under the hammer, when they may be as readily welded as iron itself. For instance, it is possible to weld together a small rod of copper which has been broken; the ends should be bevelled, laid on one another, seized by a pair of tongs, and placed together with the latter in the fire and heated; the welding powder should then be strewn on the ends, which, after a further heating, may be welded so soundly as to bend and stretch as if they had never been broken.

It is necessary to carefully observe two things in the course of the operation: 1st. The greatest care must be taken that no charcoal or other solid carbon comes into contact with the points to be welded, as otherwise phosphide of copper would be formed, which would cover the surface of the copper and effectually prevent a weld. In this case it is only by careful treatment in an oxidising fire and plentiful application of the welding powder that the copper can again be welded. It is, therefore, advisable to heat the copper in flame, as, for instance, in a gas flame. 2nd. As copper is a much softer metal than iron, it is much softer at the required heat than the latter at its welding heat, and the parts welded cannot offer any great resistance to the blows of the hammer. They must, therefore, be so shaped as to be enabled to resist such blows, and it is also well to use a wooden hammer, which does not exercise so great a force on account of its lightness as does a steel one.

WHISKY. The accepted definition of whisky is spirit distilled from a mixture of grain and malt, or malt alone. The so-called "Dublin whisky" has no exclusive right to the appellation. It is asserted that patent still spirit is called "silent," "presumably because it tells no tales with regard to the materials from which it is derived, and that spoilt barley and a variety of refuse of other kinds find their way into the patent still." Such an affirmation the Scotch distillers altogether deny. They say it is well known that there is great variety in the quality of patent still as well as in pot still spirits. Nothing but perfect grain, and care and skill in the manufacture, can produce even a partially silent spirit; and if heated or inferior grain is used, the spirit is at once condemned, and can only be sold for methylation. The real explanation of the term "silent" as applied to spirit made by the COFFEY still is, that such spirit has less flavour than pot still whisky, and on that account it is well adapted for mixing with other spirits. It is insinuated that in mixing spirits of different brands the dealers add drugs to give an artificial pungency upon the palate. The blending in bond is effected under the inspection of Government officers, and by law no drugs can be added. There being a great difference in price between pot still

and patent still spirits, the Scotch distillers think it is not surprising that dealers should buy a large portion of the latter, more especially as they know it is as pure and wholesome as any whisky that can be produced in Dublin or elsewhere. Blending is a matter of skill and experience. Each dealer has his own blend, as many believe that whisky of different brands, when mixed, is softer and more palatable than the whisky of any one distillery. Patent still whisky is, to a large extent, kept for years in bond in sherry casks, both in Scotland and Ireland, in the same way as Dublin whisky, and, when matured with age, is an extremely fine and palatable beverage, by many preferred to pot still whisky. It is this old spirit which is often used in blending. Government interference is not required for the protection of the consumer, who can always be sure of getting the spirit of any particular distiller if he desires it, for each distiller has his own brand and trade mark, and the presence of the word "blended" on the head of every cask containing blended spirit, as well as the permit, proclaim whether the spirit he buys is unmixed or blended. The only possible justification for the Government interference would be that without it injury to the public health must arise. But such a plea could not be for one moment urged, for, although statements as to the alleged deleterious character of Scotch spirit have been industriously spread, they are not only without foundation, but the opposite of the truth.'

Messrs. John Haig and Co., of the Cameron Bridge Distillery, Fifeshire, remark on the above:—

'The article, in defining the difference between Scotch and Irish whisky, says: "Genuine or original Scotch whisky differs from Irish in being distilled from a barley mash only, without malt; and in Ireland a certain quantity of whisky has been distilled from a malt mash alone." Every practical distiller knows that no grain mash, whether made from barley, wheat, or Indian corn, can be worked without a large percentage of malt. But, independent of this, "genuine or original Scotch whisky" (such as Glenlivat, Islay, or Campbelton) is made from nothing but pure malt, and we know for certain that "genuine" Dublin whisky is almost never made from malt alone, but from 25 to 40 per cent. of malt, and the rest barley, or wheat and oats. As to the process of manufacture, what is there to prevent whisky made from similar materials, in stills of identical shape and construction, but situated in Scotland, being equal to and identical with Dublin whisky? We engaged an experienced distiller, for many years manager of one of the best Irish distilleries, to teach us the Irish method of manufacture. We work good barley, similar to what we see bought every week in our Scotch corn markets to be shipped to the Dublin distillers, and we maintain that our results are identical in quality and manufacture with Dublin whisky. The difference is in the price. The Dublin men have had a monopoly of late years, and have worked it well. In Scotland we must be content with smaller profits, and we can afford to sell our whisky for something less than 6s. per gallon. Our process of manufacture is open to every genuine inquirer. We have nothing to do with "prune wine," "essence of sherry," or "Hamburg sherry." We call our whisky simply "old still," or "pot still" whisky, which it undoubtedly is.'

WHORTLEBERRIES. *Used to adulterate wines.* See WINES, ADULTERATION OF.

WINE. (Vol. iii. p. 1135; CHAMPAGNE WINES, &c., p. 1143.)—The following remarks on *Sparkling Hock* are from the pen of a well-known writer, and are borrowed from the *Pall Mall Gazette.* They supplement what has already been stated respecting effervescing wines:—

'For some years the great anxiety of the manufacturers of sparkling hocks was to render their wines as much as possible like champagne, which was only to be accomplished by disguising their true flavour and dosing them largely with syrup. In this form they satisfied, and indeed still satisfy, their German and Russian consumers, but of late years the character of the wines for the English market has undergone a complete change. England has set the example of a decided preference for the drier kinds of sparkling wines. And in this we have shown our wisdom, inasmuch as low-class wines devoid of flavour, or possessing a flavour that is objectionable, can have these drawbacks disguised by a liberal dose of syrup. In dry sparkling wines, on the contrary, the actual flavour of the original wine—the *vin brut*—is preserved, which necessitates wines of a comparatively high class being employed in their manufacture. The principal difference between champagnes and sparkling hocks designed for the English market consists in the former being made almost exclusively from red grapes, pressed immediately they are gathered, and not allowed to ferment in their skins, while the latter are made from white grapes alone. The finest champagnes come from the *pineau noir*, or black Burgundy grape, while the best sparkling hocks are made from the Riesling, and the commoner kinds chiefly from the Kleinroth variety, the latter being a red grape. Effervescing Rhine wines of the highest class have a marked and refined flavour, together with a very decided bouquet. Moreover, they

retain their effervescent properties for a considerable time after being uncorked, and appear to the taste quite as light, if not precisely as delicate, as the higher class champagnes, although in reality such is not the case, for all sparkling hocks possess greater body than even the heaviest champagnes, and, therefore, cannot be drunk with equal freedom. The process pursued in the manufacture of sparkling hocks is, with a single variation, precisely the same as that followed with regard to champagnes, the difference being that in the case of hocks the raw wine, after the fining which takes place following its first fermentation, has a small quantity of sugar added to it previously to being put into bottle. After it is bottled the wine remains in a cool cellar for eighteen months or a couple of years, being constantly moved during this period, in the same way as champagne is, to force the sediment which it forms to deposit itself near to the cork. By this time the added as well as the natural sugar contained in the wine has become converted into alcohol and carbonic acid; and after the sediment has been expelled from the bottle the operation of dosing, or flavouring, the wine takes place. According as this is required to be sweet or dry, a larger or smaller quantity of liqueur is added to it; and, with regard to sparkling hocks destined to the English market, the dose is generally of a *minimum* description. Indeed, the finest qualities from such houses as MÜLLER, of Eltville, and EWALD, of Rudesheim, which are to be obtained in England much cheaper than second-class champagnes, are even drier, and consequently more natural, wines than most of the champagnes we are acquainted with. Foreigners cannot understand our preference for dry, sparkling wines. They do not consider that as a rule we drink them during dinner with the *plats*, and not at dessert, as they almost invariably do, with all kinds of sweets, fruits, and ices. Sparkling hocks for the home and Russian markets are frequently almost cloying in their sweetness. The sparkling Moselles, too, for Russia are largely dosed with the preparation of elder flowers, which imparts to them their well-known muscatel flavour and perfume. The manufacturers say they are doing their best to abandon this absurd practice of artificially perfuming sparkling Moselles; but many of their customers, and especially those in the English provinces, stipulate for the scented varieties, possibly from an erroneous belief in their superiority. Great impetus was given to the manufacture of German sparkling wines during the recent war, when the champagne was in a measure closed to the outside world. At this epoch the less scrupulous manufacturers, instigated by dishonest speculators, boldly forged both the brands on the corks and the labels on the bottles of the great Rheims and Epernay firms, and sent forth sparkling wines of their own production to the four quarters of the globe as veritable champagnes of the highest class. The respectable firms acted more honestly, and, as it turned out, with better policy, for by maintaining their own labels and brands they extended the market for their produce, causing German sparkling wines to be introduced under their true names into places where they had never penetrated before. The result was a considerable increase in the annual demand, even after the stores of CLICQUOT, ROEDERER, MOËT, and MUMMS were again open to all the world. Owing to this increased demand, and the deficient supply of Rhine wines at moderate price, the manufacturers of sparkling hocks are reduced to follow the example of the champagne firms, and buy much of their raw wine at a distance; and this year they have had to pay double the price of six years ago for suitable wines of the Palatinate. Among the principal manufacturers of sparkling hocks are included the two firms already mentioned—MATHEUS MÜLLER, of Eltville, and EWALD and Co., of Rudesheim—together with the HOCHEIMER ASSOCIATION, at Hochheim, and the RHEINGAUER ASSOCIATION, at Schierstein. These four firms produce annually about a million and a half of bottles between them, or nearly double their production of eight or ten years ago. KEITH, of Coblenz, and LAUTEREN and SON, of Mayence, are also manufacturers on an extensive scale, as well as of considerable repute. So widespread now is the manufacture of German sparkling wines—so-called hocks and Moselles—that it forms an important branch of industry not merely in the Rheingau and at Coblenz and Mayence, but also at Trèves, where sparkling Moselles are extensively made; in the Nahe valley, at Wurzburg in Bavaria, where the best vineyards are owned by the king; and by far the best sparkling wine is made at the royal factory, at Esslingen in Würtemberg, at Berbheim in Alsace, and at Grüneberg in Prussian Silesia. Next to the home the principal market for sparkling hocks is Great Britain. Afterwards come the North of Europe, the United States, Australia, China, and Japan. The cheapness of these wines no doubt tells largely in their favour, as the commoner kinds can be purchased as low as 2s. per bottle, while the higher qualities average no more than 4s., excepting in the single instance of sparkling Johannisberger, not *schloss* Johannisberger, which is priced at 5s. 6d. the bottle.'

WINES, ADULTERATION OF. Dr. THUDICHUM, M.D., has given in the *Times* the following valuable remarks on the adulteration of sherry:—

'Sherry—that is to say, the wine grown and made at Jerez for consumption in

England—is the product of two varieties of vines mainly, the palomino and mantuo castellano. Each quantity of collected grapes, sufficient to yield a butt of must, previously to being trodden and pressed, is invariably dusted over with from 30 lb. to 40 lb. of burnt plaster of Paris (sulphate of lime). The effect of this practice, of which my inquiries among sherry makers have not taught me the object, is to precipitate all tartaric and malic acid of the must and substitute in their place sulphuric acid. The must, therefore, as it runs from the press, contains no bitartrate of potash, or so-called tartar, but sulphate of potash instead. In consequence all sherry contains nearly the whole of the potash of the must as sulphate, amounting to from 1½ kilogram (about 3 lb.) to 7 kilograms (about 14 lb.) per butt of 484 litres, or 108 gallons.

'The common varieties of must are not only plastered, but also impregnated with the fumes by combustion of about five ounces of sulphur per butt, which adds about a pound of sulphuric acid to that brought in by the plaster. The plastered must, as it runs from the press, contains its fruit, sugar, tannin, and other ingredients in a perfectly developed condition, and the statement of one of your correspondents that they were in an undeveloped state is scarcely intelligible. Quantitative determinations made upon many and different specimens of must at Jerez show that its specific gravity varies between 9° and 14° of BAUMÉ's areometer, indicating from 14·6 to 24 per cent. of sugar, and that, therefore, it can by fermentation only form from 14 to 23 per cent. of proof spirit.

'The must ferments in the sheds called bodegas, there being no cellars properly so-called at Jerez. In a fortnight the sugar has all fermented away, and the must is transformed into wine. This is allowed to deposit its lees during some months, and is racked in the following February or March. On this occasion some brandy is added to the wine, by which its alcoholicity rises to about 29 per cent. of proof spirit. In spring and early summer the wine (still termed "mosto," and so to the time of the next harvest), undergoes what is termed its first evolution, and after that is ready for further preparation.

'This consists in the addition of various ingredients which impart colour, sweetness, spirit, and flavour. Colour is imparted by the addition of caramel, produced by the boiling down in coppers of previously plastered grape-juice; the brown syrup is dissolved in wine and spirit, so as to form a deep brown liquid, containing from 35 to 50 per cent. of proof spirit, termed "color," or "vino de color." Frequently caramel made from cane-sugar is used instead of that made from grapes. Some colour is made with the juice of rotten or otherwise inferior grapes. Sweetness is imparted by the addition of "dulce,"—that is, must, frequently made from grapes dried for some days in the sun, to which one-sixth of its volume of spirit, of the strength of 40° by CARTIER's alcoholometer, has been added (a process by which all fermentation becomes impossible). Every hundred litres of dulce contains, therefore, 10 litres of absolute alcohol, equal to 33·78 per cent. of proof spirit. Flavour is imparted by the addition of some old selected wine, which is kept in so-called "soleras." Ultimately brandy is added to the mixture to the extent of fortifying it up to 35 as the minimum, most frequently up to 40 or 42, and sometimes, as your Custom-house correspondent proved, up to 50 per cent. of proof spirit.

'In a butt of ordinary sherry (40 jars) there is mostly one-fifth of its volume of dulce (eight jars); consequently, about one-sixth of unfermented grape-juice, and which remains unfermented. This is, therefore, opposed to the statement of one of your correspondents that it would be impossible to find a single drop of unfermented grape-juice in sherry. The better sherries are made less sweet, and only the few finest varieties are left unsweetened. The "dulce" is never plastered, and, therefore, its addition depresses a little the large quantity of sulphate of potash introduced by the "color."

'Now it must be observed that what has been described is the process of making "sherry," and not a process of adulterating it. It may be a question whether this process leaves much room for adulteration, or whether it is not itself adulteration; in other words, whether all sherry whatsoever is or is not adulterated. To help your readers towards a solution, I remind them that medical authorities have long since pronounced the brandied and plastered sherries to be unwholesome. But the vendors of such sherries are not troubled by the administrators of the Acts of Parliament relating to adulteration. On the other hand, bakers who mix a little alum with their flour or dough, which in the bread reappears as sulphate of potash (the same as in sherry) and phosphate of alumina (perfectly innocuous), are prosecuted, fined, and denounced, though their additions considered as per cent. of bread are incomparably smaller than the additions made to sherries considered as per cent. of wine.

'Sherries contain from 1½ to 6 grams of sulphuric acid as potash salt per litre, and the more the older and better they are; most "soleras" are near the highest figure. Now if alumed bread is unwholesome, plastered sherry must be unwholesome also, and is more so.'

Althæa Rosea or *Hollyhock* is much used for adulterating wines. This colouring matter imparts a peculiar flavour to the wine, which in a few months becomes very disagreeable, while the colouring matter itself is rapidly precipitated.

Archil.—If archil be present the ethereal solution is red.

A skein of white silk is dyed rose red by soaking it in a wine adulterated with archil, and its colour passes to yellow in treatment with hydrochloric acid, but to a bright rose if the wine is pure.

Archil residues, sulpho-purpuric acid, and sulpho-alizaric acid and their salts, are sometimes employed in colouring wine.

Beetroot is generally employed to disguise other adulterations. If to the clarified wine (egg-albumin) bicarbonate of soda be added, yellowish colours are produced, especially if the beetroot is fresh. Baryta is very sensitive for detecting beetroot with old decoctions.

Black Elder and *Dwarf Elder.*—The dwarf elder communicates a faintly terebinthinous odour. The berries of both varieties are particularly used to impart a special colour and flavour to port wine. The *Teinte de Fismes* is much used. See TEINTE DE FISMES.

M. MATHIEU reports having discovered as much as from 4 to 7 grains of alum per litre in wines adulterated with this compound. Sometimes the alum is replaced by tartaric acid. If the suspected wine is clarified with egg-albumen and alum be added, and then a solution of carbonate of soda, a violet-blue-lake is obtained. A piece of flannel, or a skein of silk mordanted with acetate of alumina, heated for some time in the suspected wine, then washed and immersed in water made faintly alkaline with ammonia, becomes green if the wine is pure, but dark brown if black elder is present, and probably a similar reaction occurs with dwarf elder.

Brazil Wood, to detect.—To about one-tenth of the volume of the wine suspected, egg-albumin diluted with 1½ times its bulk of water should be added and well shaken. This will not wholly decolorise the adulterated wine. It becomes yellow-buff, and on exposure to air it gradually acquires a new red.

If a wine which has been adulterated with Brazil wood is clarified as above, and then a skein of scoured silk washed with dilute tartaric acid is soaked in it for 24 hours and then withdrawn, washed and dried at 60–70° C., the silk will be found to be dyed lilac-maroon or red. The skein remains wine-coloured or lilac in pure wine. If the dyed silk be now dipped in dilute ammonia and then heated to 100° for a moment, it becomes, if the wine has been adulterated with Brazil wood, a lilac-red. If the wine is pure the change would be to a deep grey, with scarcely a tinge of the original colour. If the ammonia be replaced by lime-water, the skein changes to ash-grey if Brazil wood was present, but to a dark, dirty yellowish-red if the wine is pure. Finally, if the dyed skein be dipped in acetate of alumina and then be heated to 100° C., it retains its wine-red lilac colour. This reaction distinguishes Brazil wood from logwood.

Cochineal.—The suspected wine should be clarified as for Brazil wood—with egg-albumin. Then a skein of scoured silk mordanted with the acetate of alumina should be soaked in the wine for 20 hours. It is dyed of a wine-violet colour analogous to that of a pure wine on being dried at 100° C.

The colour does not change at this temperature when treated with acetate of copper, but if the skein be dipped into a dilute solution of chloride of zinc, heated to 100° C., and then wetted with carbonate of soda, washed with water and dried, the silk becomes of a fine purple colour, whereas with pure wine the tint remains of a sombre grey-lilac.

The spectroscope will detect cochineal if present in large quantities, but if it amounts to only 12 per cent. of the total coloration this instrument will not detect it.

Fuchsine.—The following processes for detecting this colouring matter are given by M. E. JACQUEMIN (*Bull. Soc. Chim.* [2], xxvi. p. 68):

1st. *By the direct Dyeing of Gun Cotton.*—A wad of gun cotton is heated for a few moments in about 20 c.c. of the wine, then withdrawn and washed with water. Fuchsine and archil (which is sometimes used to increase the colour of wines) both dye it, whereas the natural colour of the wine does not. These two may be distinguished by moistening the dyed cotton with ammonia, which changes the archil to violet and blanches (though slowly) the fuchsine. Gun cotton which is undergoing change is more efficacious than that which is pure and new.

2nd. *By the direct Dyeing of Wool.*—Wool is scarcely affected by the natural colouring matter of wine, but is dyed by fuchsine and archil. About 100 c.c. of wine are evaporated till the alcohol is removed. A piece of colourless embroidering wool (Berlin wool) is then immersed in it, and the evaporation continued till the bulk is reduced one-half, when the wool is withdrawn and thoroughly washed. The tints of fuchsine and archil are slightly modified by the natural colouring matter of the wine.

but on treatment with ammonia the last mentioned changes to brown, whilst the fuchsine is rapidly dissolved, and the colourless ammonia solution becomes red on acidification. The archil becomes violet, and imparts that colour to the ammonia in which it is dipped.

3rd. *By Dyeing Wool with Ammoniacal Fuchsine.*—The alcohol is evaporated from 100 or 200 c.c. of the wine, the remainder made alkaline with ammonia and then shaken with ether. The colourless ethereal solution is evaporated on a piece of white wool, which becomes dyed as the evaporation proceeds. The destruction of this colour by ammonia and its reproduction by acetic acid leave no doubt as to the nature of the colouring matter.

Place a few grams of the wine in a phial and add ammonia. Into the mixture dip a piece of white Berlin wool, and when it is well soaked withdraw it, and allow a drop of vinegar or acetic acid to run down it. The wool becomes quite white if the wine is pure, but is tinted red if fuchsine is present, the depth of the colour being proportional to the quantity of colouring matter used.—C. Husson, 'Detection and Estimation of Fuchsine and Arsenic in Wines which have been artificially coloured with Fuchsine,' *Comptes Rendus*, lxxxiii. p. 199.

Another test is to mix 100 grams of the suspected wine with 15 grams of coarsely-powdered dioxide of manganese, shaking for a quarter of an hour, and filtering through a double filter paper. If the wine is pure it passes through colourless; if adulterated, some artificial colouring matter has been used.—'Detection of Artificial Colouring Matter in Wines,' by L. Lamattina, *Comptes Rendus*, lxxxiii.

Indigo.—Wool or silk mordanted with acetate of alumina, heated with 20 to 40 c.c. of the suspected wine nearly to dryness, washed and then dipped into a very dilute solution of ammonia, becomes dirty green if the wine be pure, but blue if a trace of indigo be present. Indigo being often used to disguise the too bright colours of cochineal and fuchsine, they should always be sought for after the removal of the indigo by clarification with albumin.

Indigo very rapidly separates from the wine, and it may be frequently found in the lees, even when the wine gives but little indication of its presence.

Logwood.—The wines suspected to be coloured with logwood should be treated with egg-albumin, as ordered in the case of Brazil wood. The precipitate obtained is washed with water, then with alcohol of 25 per cent. A part is then removed and boiled with alcohol of 85 per cent. and filtered. Treated with a skein of silk, the silk is dyed maroon or lilac-red, is changed by diluted ammonia to a violet-blue tinged with grey, and by acetate of alumina to a bluish violet.

Privet Berries are very seldom used. The presence of their juice may be detected by adding acetate of alumina to the clarified wine, or the peroxide of barium and a little tartaric acid. An orange colour deposit takes place after about 18 hours.

Whortleberries are only used for the most common wines. In wines adulterated by the juice of this fruit citric acid may almost always be detected.—'On the Fraudulent Coloration of Wines', by Arm. Gautier, *Bull. Soc. Chim.* [2], xxv. p. 483, &c.

Campeachy Wood, Archil, &c.—From 5 to 6 millilitres of the wine are to be poured into a glass test tube of 20 m. capacity, and then three-fourths of its bulk of ether is added. After a few minutes the ether rises to the surface. If the ether be coloured yellow, and assumes on adding a few drops of ammonia a deep red tint, Campeachy wood has been used to colour the wine. If the ether becomes red or violet, and remains so on the addition of ammonia, the colouring matter has been derived from the lichens.—Mellias; Dingler's *Polyt. Jour.*, ccxv.

A test-paper has been prepared and sold under the name of *Oenokrine* by MM. Lainville and Roy, which appears to answer well.

With a genuine red wine the colour produced is a greyish blue, which becomes lead coloured on drying. With magenta and other aniline colours it turns a carmine red; with ammoniacal cochineal a pale violet; with elder berries, the petals of roses, and the like, a green; with logwood and Brazil wood the colour of the dregs of wine; with Fernambuco wood and Phytolacca a dirty yellow; with extract of indigo a deep blue. The manipulation required is simple. A slip of the paper is steeped in pure wine for about 5 seconds, then briskly shaken to remove the excess of liquid, and placed on a sheet of white paper to serve as a standard. A second slip of the same paper is put into the suspected wine, and then placed beside the standard piece. It is asserted that 1-100,000th of magenta in wine is sufficient to give the paper a violet shade.—Les Mondes, *Revue Hebdomadaire des Sciences*, November 23, 1876.

Optical Behaviour of Wines.—It appears that commercial grape sugar contains considerable quantities of an unfermentable body, varying from 16 to 24 per cent. This substance is partly soluble and partly insoluble in alcohol; it is not sweet, nor does its concentrated solution deposit dextrin on addition of alcohol. It is neither gum nor sugar, but it may be transformed into sugar by long-continued boiling with dilute

sulphuric acid. The substance is non-crystalline, and it very slightly reduces copper from Fehling's solution.

Ordinary wines exert no rotatory action on the polarised ray when fermentation has ceased, but very fine German wines, as Johannisberg and Rüdesheimer, cause the ray to rotate to the left; hence if it be found that a sample of wine causes right-handed rotation, we may conclude that this sample is adulterated with commercial grape sugar. —C. Neubauer, 'Optical Behaviour of Wines,' *Zeitschr. Anal. Chem.* 1876.

Importations of Wines.—On May 9, 1866, an Act was published settling that all wines containing less than 26 degrees of proof spirit should pay 1s. a gallon duty; containing 26 and less than 42 degrees of proof spirit, 2s. 6d. per gallon; and additional, for every degree of strength beyond the highest above specified, 3d. per gallon.

Red Wine.

	1875		1876	
	Gallons	Value	Gallons	Value
From Germany	72,382	£14,402	98,046	£19,829
" Holland	44,006	19,441	48,403	18,278
" Belgium	4,500	2,579	5,965	2,687
" France	3,635,947	1,011,682	5,366,832	1,374,941
" Portugal	4,442,760	1,478,564	3,959,064	1,267,815
" Madeira	301	130	595	32
" Spain	1,365,586	179,471	1,289,027	156,692
" Canary Islands	217	95	—	—
" Italy	20,026	6,597	26,696	7,159
" Channel Islands	13,174	6,644	14,045	6,794
" Gibraltar	3,251	1,135	941	540
" Malta	186	80	309	94
" British Possessions, South Africa	5,048	2,277	5,837	2,090
" British East Indies	1,008	570	1,736	1,074
" Australia	10,013	3,202	21,566	6,006
" other Countries	15,617	6,773	14,413	4,445
	9,639,519	£2,734,241	10,853,651	£2,871,594

White Wine.

	1875		1876	
	Gallons	Value	Gallons	Value
From Germany	337,943	£45,556	323,928	£42,007
" Holland	536,727	346,947	375,963	374,070
" Belgium	9,307	5,747	12,022	6,869
" France	1,645,867	1,506,296	1,093,313	1,530,555
" Portugal	35,337	8,957	19,651	6,156
" Madeira	91,697	47,550	120,307	61,654
" Spain	5,526,150	1,942,556	5,907,089	1,917,946
" Canary Islands	6,563	2,705	7,962	2,172
" Italy	458,036	105,156	600,091	122,552
" Channel Islands	11,711	5,590	8,054	4,642
" Gibraltar	14,030	8,428	10,208	6,093
" Malta	10,388	3,968	10,084	3,138
" British Possessions, South Africa	6,164	3,097	8,111	3,076
" British East Indies	21,698	14,060	23,757	13,071
" Australia	15,230	4,753	27,895	12,609
" other Countries	31,019	14,370	33,627	13,712
	8,769,780	£4,066,774	9,097,172	£4,121,505

The following table shows the quantity of wine entered for home consumption, and the amount of duty received thereon, as far as regards the importations of wine from France, Portugal, and Spain:—

	1875			
	Red		White	
	Gallons	Value	Gallons	Value
France . . .	3,502,516	£180,745	1,536,599	£70,651
Portugal . . .	3,862,071	481,500	25,219	2,934
Spain . . .	1,133,476	130,362	5,643,180	694,641
	1876			
	Red		White	
	Gallons	Value	Gallons	Value
France . . .	5,147,866	£262,315	1,607,554	£83,148
Portugal . . .	3,697,150	461,241	28,246	3,236
Spain . . .	1,134,075	137,695	5,827,266	655,507

Wines imported in 1877.

		Gallons	Value
From British Possessions in South Africa		28,206	£10,926
" other British Possessions		20,201	6,615
" Germany		461,310	66,466
" Holland		621,771	369,760
" France	Red	1,811,682	1,406,344
	White	1,831,010	1,664,499
" Portugal		4,099,665	1,345,727
" Madeira		54,264	43,294
" Spain	Red	1,263,862	162,358
	White	5,553,161	1,658,437
" Italy		732,004	146,820
" other Countries		125,807	64,263
Total	Of Wine	16,630,903	£7,155,700
	Red	9,548,173	2,970,376
	White	8,123,100	4,185,328

Wines entered for Home Consumption.

		Gallons
From France	Red	4,725,681
	White	1,090,307
" Portugal		3,648,462
" Spain	Red	1,073,034
	White	4,075,829
" other Countries		1,657,970
Total	Of Wine	17,671,273
	Red	9,548,173
	White	8,123,100

WIRE GAUGE. At a meeting of the Board of Directors of the Pittsburgh Chamber of Commerce, United States, the Committee on Wire Gauges presented the following paper:—

'Your committee appointed to examine into and report in regard to memorialising Congress on the adoption of a standard wire gauge, would respectfully submit the following:—For many years past all classes of manufacturers, contractors, and buyers of metals usually made or sold by thickness determined by wire gauge, have felt the great need of the adoption of a standard gauge, and one which was made standard by legal enactment. There are about thirteen known gauges, and with perhaps but one exception none of them are constructed on any defined system.

'As an example of the irregularity of increase of thickness by number of wire gauge, we will take the Birmingham gauge, which is most generally used by our iron manufacturers here.

'No. 24 sheet iron weighs 95 lb. per sq. ft.
'No. 23 sheet iron weighs 99 lb. per sq. ft. Increase over No. 24, ·04 lb.
'No. 22 sheet iron weighs 1·15 lb. per sq. ft. Increase over No. 23, ·16 lb.
'No. 21 sheet iron weighs 1·32 lb. per sq. ft. Increase over No. 22, ·17 lb.
'No. 20 sheet iron weighs 1·41 lb. per sq. ft. Increase over No. 21, ·09 lb.
'No. 19 sheet iron weighs 1·70 lb. per sq. ft. Increase over No. 20, ·29 lb.

'Aside from the irregularity of increase of size in a single gauge, the different gauges vary from 10 to 30 per cent. in corresponding numbers. Many parties not being aware of this fail to specify in their contract the name of gauge required, or the weight per foot, and thus the door is opened to a kind of dishonesty the law does not reach.

'A number of years ago the firm of Messrs. J. R. Brown and Sharpe—now Darling, Brown, and Sharpe—of Providence, Rhode Island, designed a new gauge on very simple principles, the thickness of each number increasing in "geometrical progression." This gauge, which they named "Standard Wire Gauge," has been adopted as the standard by the brass manufacturers of this country. A meeting of the wire manufacturers was held at the Astor House, New York, in 1864, at which a resolution was passed adopting the same gauge as their standard, but the meeting failing to agree on other matters appertaining to their trade, the whole fell through.

'Some of our manufacturers are not in favour of any gauge being made standard except those in use in their respective works, but it must be remembered that the making of any particular gauge a legal standard does not take away the right of private contract. It matters but little what gauge the Government may adopt, but it is a matter of great importance that some one should be made a legal standard on which contracts could be enforced in the absence of special agreements as to which particular gauge is intended.

'At the same time we think best that when a standard is adopted it should be one constructed on a perfected system, and up to this time we believe the only one so constructed is the "Standard Wire Gauge" manufactured by Messrs. Darling, Brown, and Sharpe, and we would recommend that Congress be memorialised to adopt it as the legal standard.

'The same need of a standard wire gauge has been long felt in England, and we hope the adoption of one by this country may be followed by similar action on the part of the British authorities; whether or not, we think the very small proportion of iron now imported should not be permitted to interfere with the adoption of a great improvement, which will be greatly beneficial to every trade or buyer in which any kind of goods are sold or contracted for by wire gauge.

'J. T. Stockdale,
'Geo. W. Hailman,
'O. P. Scaife.'

Through the kindness of Mr. O. P. Scaife, one of the above committee, and who has given some thought to this subject, the *American Manufacturer* has been furnished with the following copy of resolutions acted upon by the wire manufacturers of the United States at the Astor House, New York, in 1864, and though they were not adopted, owing to other questions arising at the time, the American gauge is considered standard by them:—

'Whereas it seems desirable that a uniform standard gauge be used by all American wire manufacturers, therefore,

'Resolved, that on and after April 1, 1864, we, the undersigned, will adopt the gauge prepared by Messrs. J. R. Brown and Sharpe, of Providence, R.I., known as the American gauge, and will be governed by it in the manufacture of iron wire, and also use our exertions to have it brought into general use.'

Mr. Scaife furnishes the table on the following page, which shows the difference between the proposed American gauge and the Birmingham gauge.

'In the American gauge the graduations are calculated as follows, the different numbers increasing in geometrical progression, so that having the size of one number any other number can be found by a simple calculation:—

'Let A = the first term in a geometrical series of numbers.
B = the last term.
N = number of terms.
R = ratio or factor by which the terms are multiplied.

'Therefore, if A = ·005 in. or No. 36 gauge, B = ·46 in. or No. 0000, and N = 40:—

$$R = \sqrt[N-1]{\frac{B}{A}} = 1·123$$

'Each term, commencing with ·005 or No. 36, being successively multiplied by this factor, gives the successive sizes, and any intermediate size may easily be found by calculation.'

No. of Wire Gauge	New Standard		Birmingham Gauge	
	Size of each No. in Decimal parts of an Inch	Difference between Construction Nos. in Decimal parts of an Inch	Size of each No. in Decimal parts of an Inch	Difference between Construction Nos. in Decimal parts of an Inch
0000	·460	—	·454	—
000	·40964	·05036	·425	·029
00	·36480	·04484	·380	·045
0	·32486	·03994	·340	·040
1	·28930	·03556	·300	·040
2	·25763	·03167	·284	·016
3	·22942	·02821	·259	·025
4	·20431	·02511	·238	·021
5	·18194	·02237	·220	·018
6	·16202	·01992	·203	·017
7	·14428	·01774	·180	·023
8	·12849	·01579	·165	·015
9	·11443	·01406	·148	·017
10	·10189	·01254	·134	·014
11	·09074	·01115	·120	·014
12	·08081	·00993	·109	·011
13	·07196	·00885	·095	·014
14	·06408	·00788	·083	·012
15	·05707	·00702	·072	·011
16	·05082	·00625	·065	·007
17	·04526	·00556	·058	·007
18	·0403	·00496	·049	·009
19	·03589	·00441	·042	·007
20	·03196	·00393	·035	·007
21	·02846	·00350	·032	·003
22	·02535	·00311	·028	·004
23	·02257	·00278	·025	·003
24	·0201	·00247	·022	·003
25	·0179	·00220	·020	·002
26	·01594	·00196	·018	·002
27	·01419	·00174	·016	·002
28	·01264	·00155	·014	·002
29	·01126	·00138	·013	·001
30	·01002	·00123	·012	·001
31	·00893	·00110	·010	·002
32	·00795	·00098	·009	·001
33	·00708	·00087	·008	·001
34	·0063	·00078	·007	·001
35	·00561	·00069	·005	·002
36	·005	·00061	·004	·001
37	·00445	·00055	—	—
38	·00396	·00049	—	—
39	·00353	·00043	—	—
40	·00314	·00039	—	—

WIRE-GAUZE WEAVING. Wire-gauze weaving by hand-loom is performed in the following manner:—The warps are wound on the beam, and secured to the winding-off beam, two treadles only being required, which are, by the usual arrangement, prepared to raise the warps alternately, the motion being given through treadles worked by the foot at the lower part of the loom, or by lighter levers on the upper part. The weft is wound on the bobbins fitting into the shuttles, which are preferred when made of brass, cast light, as it glides easily along the metallic warps, requiring no 'unction,' as is sometimes the case when other material is used. Box or other suitable wood is used for the shuttles, which are made fish-shaped, being a natural

one for the duty they have to perform. The shuttles carry the bobbins in their hollow centre in such a manner that they can revolve with sufficient freedom during their flight across the warps.

Supposing a breadth of from 4 to 6 feet is to be woven, two weavers would be employed, one to throw the shuttle from right to left, the other from left to right, somewhat in this fashion:—The right-hand man makes a loop or knot on the loose end of the weft, and with his left hand mechanically secures it to a peg or hook for forming the selvage. Next, with a measured action acquired by practice, he takes the shuttle in his right hand, in so doing liberating a sufficient length of the weft between his fingers until his arm has proper play for throwing the shuttle, which he does very mechanically, the shuttle being caught with equal precision by the left-hand man, who gives the weft a slight strain, and holds the shuttle in his left hand, while with the other he assists his mate to give the lay a stroke and drive the weft up to its required position. The warps are then *reversed*—that is, the upper take the place of the lower, and *vice versâ*, by a movement of the treadles or levers, as the case may be; the same operation is repeated by the left-hand man. Each stroke of the lay advances the weft the distance required, leaving space for open tissues, such as wire-gauze. In this way from 50 to 150 square feet can be woven in a day of ten hours. Now all these movements are so purely mechanical that it is surprising that they have not been done by power long before this.

WOOD-WORKING MACHINERY. (See CARVING BY MACHINERY, vol. i. p. 736; CASK, vol. i. p. 744; WOOD-PRESERVATION, vol. iii. p. 1155.) In addition to the articles referred to, there will be found in the preceding volumes, scattered through the articles which have a direct or indirect reference to wood-manufactures, statements connected with the use of machinery for forming wood into shape. The present article will deal with such machines as have not been previously noted. To do this to the extent required by the large number of beautifully constructed machines which are now in use, a volume would be scarcely sufficient, consequently a general statement, referring to typical pieces of machinery only, is all that can be introduced in this place.

The first operation is, of course, the felling of the tree. This has been, and is usually, the work of the woodman. Recently, however, the firm A. RANSOME and Co., of the Stanley Works, Chelsea, have introduced a 'steam tree-feller.'

It consists of a steam cylinder of small diameter, having a long stroke, attached to a light cast-iron bed-plate, upon which it is arranged to pivot on its centre, the pivoting motion being readily worked by a lever. The saw is fixed direct to the end of the piston-rod, which is caused to travel in a true line, when at work, by guides; and the range of the pivoting motion of the cylinder is such as to enable the saw to pass through the largest logs that are ordinarily to be met with, without moving the bed-plate. A strong wrought-iron strut is attached to the bed-plate, and this is furnished with two fangs, which are made to bite into the butt of the tree by a chain passed round it just below the saw-cut, and drawn taut by a powerful screw.

The machine is supplied with steam at a high pressure from a small portable boiler through a strong flexible steam pipe, and as this may be of considerable length, the boiler may remain in one place until the machine has cut down all the trees within a radius which is determined by the length of the steam pipe.

From the foregoing description it will be clearly seen that the only fixing the machine requires after it is laid down against the tree, is to draw it tight against the butt by the chain and screw above referred to; and as the whole apparatus, exclusive of the boiler, does not weigh more than about 3 cwt., it is readily carried about slung on poles between four men. The steam pipe does not require to be disconnected while the machine is being removed, and a special valve is attached by which it can be instantly started at any part of the stroke.

Sawing Machines.—The machines employed for converting rough timber are very numerous, and several exceedingly ingenious sawing machines have been introduced by different inventors for this purpose.

For a permanent saw-mill, where logs from 12 in. to 30 in. in diameter are required to be sawn into boards of various thicknesses, a vertical timber-frame is required. These log frames are made of all sizes, to suit both large and small work. If the logs are tolerably straight and level on the under-side, so that they get a fair bearing on the rollers, a 'roller feed frame,' of which an excellent example is prepared by the Messrs. A. RANSOME and Co., should be used, as being the most expeditious, its construction allowing of the logs following each other through the machine without intermission. On the other hand, where large logs of rough uneven timber have to be sawn into thin boards, special frames are required.

The principle known as the *Rack Feed* is combined in these frames with various special improvements to facilitate the conversion of rough and crooked timber, which

with ordinary frames is a work of difficulty, involving a considerable loss of time. The travelling carriage on which the timber is laid is made of cast iron, planed all over, and runs upon turned rollers, having wrought-iron spindles which work in planed cast-iron carriages, screwed to the floor of the mill, to the full length of the travelling carriage on each side of the saw frame. The ends of the log are held on two cast-iron carriages attached to the travelling bed, and furnished with powerful wrought-iron jaws, which are opened or closed by strong double-thread screws. These carriages have a lateral motion which enables them to follow the curve of a log; and the dogs are hinged, so as to allow of a vertical motion in the ends of the timber.

The log is supported immediately in front of and behind the saws upon two friction rollers, which can be raised or lowered so as to follow the under-side of the log; by this arrangement, no matter how irregular in form the log may be, it always gets a solid bearing to take the thrust of the saws. The advantage of this arrangement cannot be overrated, as, in tailing out the butt of a rough log in an ordinary frame there is danger of its slipping forward and crowding on to the saws, when great damage to the machine and saws is the inevitable result.

Semi-portable Log Frames, as they are called, are intended more particularly for use in the forest, where they can be driven direct from the fly-wheel of a portable engine, or in other cases where the machinery is required to be frequently removed and refixed. Although not literally portable, they are so constructed that they can very readily be taken up and refixed; and as they require but comparatively little excavation and foundation, they are strongly recommended in cases where the presence of water near the surface of the ground precludes the formation of a vault below the mill floor. Although, as strong as ordinary log frames of the same capacity, and capable of turning out quite as much work, yet by a careful consideration of their construction these frames are made at a considerable reduction upon the prices of ordinary log frames; and when the cost of foundations required for the latter is taken into account, the total cost of the portable frames, fixed for work, will be found to be not more than two-thirds of that of ordinary frames of the same capacity.

The swing frame, crank shaft, and connecting rods are of wrought iron, and the timber carriages which carry the ends of the logs are fitted with adjustable screw grips, and have a lateral motion to enable them to follow the curve of a crooked log. The feed motion is continuous, and the logs follow one another through the frame without any stoppage, the front end of one log following the back end of the previous one without the slightest interval. The rate of advance of the log can be regulated at will, and ranges from 1 ft. to 3 ft. a minute, according to the nature of the wood being sawn, and the number of the saws being used.

Band Saw Machines.—The fact that band saw machines can be constructed at a moderate cost to cut through a depth of 4 or 5 ft., coupled with the small amount of timber which they waste, and the comparatively little power required to drive them, makes them pre-eminently suited for breaking down large logs which cannot be compassed by any of the ordinary vertical frames.

Such machines have for some years been used in France, but they have hitherto not been generally adopted in this country on account of a prevailing notion that they require a professional saw-maker to keep the blades in order. This idea has arisen from a false impression that very wide saws must be employed for sawing very large logs, and hence blades as wide as 6 or 8 in. (which are exceedingly costly and difficult to keep in repair), have been used, instead of 3-inch saws, which cost but a moderate sum, and can be readily kept in order by any sawyer with a little practice, and are amply sufficient to cut through the largest logs.

The very imperfect construction of the few machines of this kind which are to be found in this country, most of which are wanting in suitable appliances for straining and packing the saws, has also tended greatly to bring them into disrepute.

The band saw constructed by A. Ransome and Co. has been designed to obviate the defects existing in other machines of this class, and has been for some time working most successfully. The timber is simply rolled on to the travelling table, which is of wrought iron, and is fixed on a level with the floor, and as the weight of the log is sufficient to retain it in its place, it merely requires adjusting with crowbars to bring it in a line with the saw. The table runs on a series of turned iron rollers which guide it in a perfectly straight line, and it is provided with a self-acting forward motion ranging from 5 to 20 ft. a minute, and with a return motion of 60 ft. a minute.

For sawing mahogany and other valuable woods the single-blade saw-frame has been introduced.

The saw works in a horizontal frame, and the timber is laid upon a strong cast-iron travelling table, the top of which is only a few inches above the level of the floor,

so that the logs can be easily canted on to it, and do not require to be lifted. This travelling table is fitted with a continuous self-acting variable feed, and has an accelerated return motion.

The swing frame which carries the saw is very light; and the strain on the saw is counteracted by a tension-bar, which gives great strength and rigidity to the frame. The guides for the swing frame are formed upon a cast-iron saddle, which rises and falls upon the planed faces of the main standards, the saddle being lowered after each cut to suit the thickness of the board required to be sawn. By a simple arrangement, the same hand-wheel which operates the screws for rising and falling the saw is made to raise or lower, in exactly the same proportion, the crank disc which actuates the frame, and thus the connecting rod always maintains the same relative position to the frame.

The saws used in these frames are very thin, and are sharpened to cut both ways of the stroke; they thus waste very little stuff, and do much cleaner work than can be done in a vertical frame.

Deal and Flitch Frames.—A few years since Mr. Charles Frazer, a saw-mill proprietor at Norwich, patented a series of important improvements in deal frames, one of which consists in the introduction of feed rollers on the fence side of the deal, working in conjunction with a wide feed roller acting on its other side. All these rollers being driven, give an enormous feeding power; and although they are all perfectly smooth, they will feed with the greatest certainty with any number of saws, and do not cause the slightest indentation in the surface of the deals.

Another improvement introduced by Mr. Frazer was to substitute for the ordinary heavy swing frame, divided into two compartments and worked by a single connecting rod (the whole working parts weighing from 6 to 10 cwt.) a pair of light frames, each driven by a separate connecting rod, and arranged so as to counterbalance each other, the weight of the descending frame with its connecting rod and saws tending to lift the ascending one. By this arrangement Frazer's deal frames can be driven at least twice as fast as any other kind; and the additional speed of the saws causes them to work much freer from sawdust, and to do cleaner work than an ordinary frame. The very striking advantages above noted will without doubt cause Frazer's frames to be generally adopted for all saw-mills where quick production and first-class work are important considerations; and the rapidly-increasing demand for them, in spite of their somewhat high prices, sufficiently marks them as the deal frames of the future. Their introduction has been somewhat retarded by the notion that such high speed must of necessity cause rapid wear and great consumption of oil; but in their construction care has been taken to provide for the extra speed, and with such success that the Frazer's frames as now made do not cost more for repairs nor consume more oil than any ordinary frame, although they are guaranteed to do double as much work.

After these remarks it is needless to say that for all saw-mills Frazer's Patent Equilibrium Deal Frames are strongly recommended; and although their extra cost sometimes causes purchasers to hesitate, it may safely be asserted that the excess in price of a Frazer's frame over that of any other will be more than covered in the first six months of its working. Indeed, so thoroughly is this now recognised, that any saw-mill proprietor adopting Frazer's frames in any district, secures the control of the trade in that locality.

These frames are constructed to take two deals or flitches instead of one, and are also fitted with two sets of feed rollers.

Self-Acting Plank Cross-Cut Saw.—This bench is intended chiefly for the use of cabinet, pianoforte, implement makers, and others who require to cross-cut wide plank, up to 6 in. or 8 in. thick, into lengths before ripping it out at the circular saw. For such purpose it is more convenient than heavier machines; besides which it has the advantage of taking less power to drive it, and it is also cheaper.

The whole machine is entirely self-contained, the countershaft which drives the saw being attached to the framing, *fig.* 2564. The operator stands immediately opposite the saw, which is brought up by a self-acting motion, thrown into gear by a lever fixed in a convenient position; and the saw, having completed the cut, retires, and when clear of the wood, stops of its own accord.

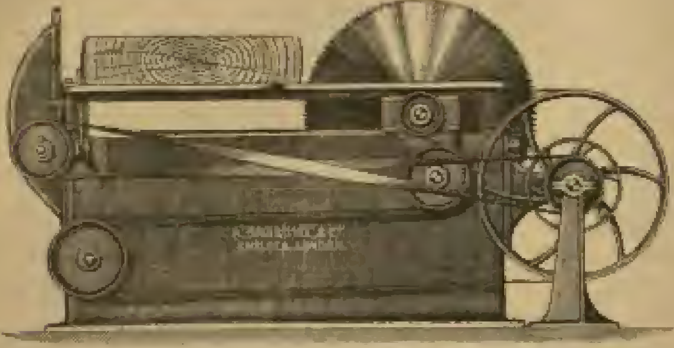
An adjustable stop is sometimes added to regulate the length of the pieces cut off, which saves the time and trouble occupied in marking and adjusting the plank.

For long plank, it is advisable to have an iron trolly running on rails to take the weight of the plank, and to facilitate its being moved up after each cut.

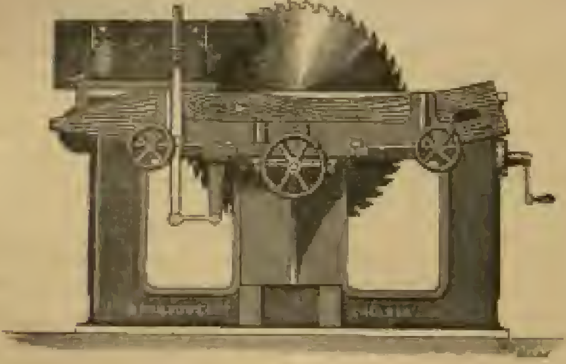
The 'Estate Carpenter,' as it has been called, is intended expressly for general jobbing work upon gentlemen's estates, such as sawing out, mortising and pointing posts and rails, ripping out fencing, cross-cutting firewood, sawing square blocks for paving, &c.

It consists of a strong cast-iron framing with a planed table, which forms a saw bench on one side capable of working saws up to 30 in. in diameter; while at the

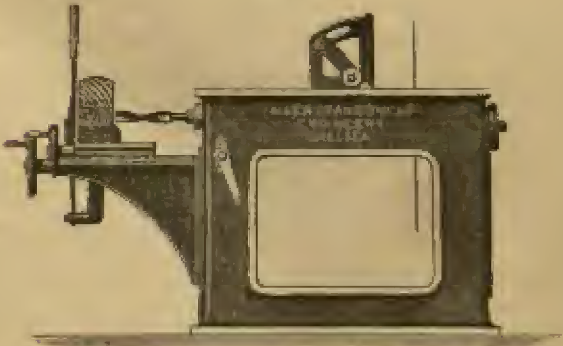
2564



2565



2566



other side is a mortising and boring apparatus, which will make mortises in any kind of wood up to 2 in. wide, and of any length and depth with great ease and rapidity (*figs.* 2565, 2566).

The driving pulley, which is fixed between the bearings, is entirely below the bench, so as to allow of timber of any length being cross-cut by the saw. A cast-iron sliding plate for cross-cutting is supplied with the machine, which works in a planed V-groove formed at the top of the table, in a line parallel with the path of the saw; this ensures a perfectly true and square cut, and prevents any cross strain on the saw. This plate is provided with a cramp lever for holding securely crooked pieces, such as boughs of trees, when being cross-cut.

The fence is adjustable to cant at any angle, and works on a round bar at the end of the table, so that it can be turned over the end of the machine and leave the top clear for cross-cutting.

The mortising table has a rising and falling motion of considerable range, so as to enable the machine to mortise large posts up to 8 or 9 in. square; and it is furnished with a peculiar cramping arrangement, by which crooked pieces can be securely held while under the action of the tool.

When used for boring, an auger is substituted for the mortise tool, and the slide which carries the wood is worked by hand.

Both sawing and mortising can be carried on simultaneously, and a man can be sawing out the posts on one side of the machine, while a lad is mortising them at the other.

Circular Saws.—We are indebted to Mr. Allen Ransome for the following remarks on these.

The following conditions are necessary to insure the satisfactory working of a circular saw:—

1. It must be perfectly flat and round, and of even thickness throughout.

2. It must be properly sharpened for the description of timber which it is required to saw.

3. It should have sufficient set to clear itself properly in work, but not any superfluous set.

4. It should be properly packed.

As regards the first of these points, it may be taken as pretty certain that saws by any of the best makers will be sufficiently true and flat, and of uniform thickness throughout; but when fitted to the saw spindle they will seldom be found to be *perfectly* round, and therefore, before a new blade is sharpened for the first time, the sawyer should fix it on the spindle, and run it round, holding a piece of hard stone to the teeth, so as to grind off any points which may project beyond the rest. As soon as it appears that every tooth has touched the stone, the saw should be sharpened, the top of each tooth being filed or ground down until all the flat faces made by the stone have disappeared, when the saw will be a perfectly true circle, and when set to work each tooth will do precisely the same duty.

The amount of set which a saw should have depends so entirely upon the quality of the timber which it has to cut, that it is best found out in practice; but the utmost care should be taken to give every tooth precisely the same amount of set, or otherwise the saw will draw in the cut. The set should be sufficient to enable the saw to clear itself properly; but as the less set a saw has the less wood it wastes, and the cleaner it does its work, it should not have more than is necessary.

The proper packing of a circular saw is quite indispensable to its satisfactory working, and therefore the greatest attention should be paid to this point. The best system of packing is to run the front part of the saw between an oiled gasket, which is tucked firmly against the saw on both sides, and rests upon wooden strips, which are screwed to the under side of the bench and filling-in plate for that purpose. The object of the gasket is not, as is frequently supposed, merely to hold the saw in position, but to create, by the friction of the blade against it, a certain amount of warmth, which should be diffused uniformly throughout the entire diameter of the saw, the result of which is to cause it to expand equally, and to run in a perfectly straight line. The whole art of packing depends upon tucking the gasket in such a manner as to insure this uniform warmth, and is readily acquired with care and practice.

It is somewhat remarkable that even in the present day a vast amount of cross-cutting is done by hand which might, to great advantage, be performed by machinery: indeed, it is quite the exception to find, even in the largest saw-mills, a machine for cross-cutting timber. This is doubtless in some measure due to the fact that most of the machines which are made for cross-cutting logs are not convenient for the purpose, and if fixed (as they should be) at the entrance of the mill, they form an obstacle to the free passage of the timber. Moreover, if a heavy log has to be fixed and cramped in a machine before it can be cross-cut, a considerable portion of the time which would have been expended in cross-cutting it by hand is lost in adjusting it in the machine. There can, however, be no doubt that a properly-

constructed machine, which will cut through a large log in less than a minute, as it lies on the ground, and yet leaves the entrance to the mill perfectly clear, is a most desirable addition to any saw-mill. If only used for cutting the butts off logs before passing to the frames or rack benches, such a machine effects a great economy but the advantage is enormously increased where timber has to be cut into short lengths before being converted.

For cross-cutting heavy scantlings, planks, deals, or other long stuff, it is desirable to employ a machine in which the saw is made to advance through the timber while the latter is at rest; for not only is it very inconvenient to hold up long heavy planks, and move them past the saw by hand, but it is very difficult in this manner to bring such pieces forward in a line exactly parallel to the plane in which the saw runs, any deviation from which tends to bend and cripple the saw. For this reason, none of the ordinary circular saw benches constructed for ripping are well adapted for cross-cutting; and moreover, as ripping benches are almost always fixed to cut in the direction of the length of the mill, it is necessary, when using them for cross-cutting, to turn the piece to be sawn across the mill, which not only involves extra labour, but is liable to interfere with the working of other machines fixed in the same building.

The saws exhibited at the Philadelphia Exhibition must be noticed here:—

A scroll saw, exhibited at Philadelphia by Beach, of Montrose, Pa., U.S., was an admirable machine. Both the upper and lower guide ways have a lateral motion either way to line the saw, also a backward and forward motion to give any desired rake to either end of the saw, while both the cross-heads are adjustable to take up all the wear, thus entirely preventing the moving of the guide ways except when made necessary by the settling of the floors. The table bed is firmly fastened to a heavy cast plate, which entirely prevents its warping or rolling. This plate is secured to the lower frame in such a manner that it can be thrown on any angle in an instant, enabling the saw to cut almost any desired bevel. Instead of the ordinary tight and loose pulley, the crank shaft carries a friction pulley, by which the saw is made to start and stop instantly without shifting the belt—a great saving of time on inside work. The operator, by a slight pressure of the foot upon the lever, can give the saw any motion that the work may demand, from 100 to 850. The friction pulley is adjustable to take up all wear, which makes it as lasting as any part of the machine. Each of the springs contains 8 ft. of ½-inch steel, made expressly for this machine, and is capable of giving a strain on the saw of 100 lb. The connections between the springs and saw are such that, while the saw moves 6¼ in., the average movement of the springs is not more than one-twelfth of an inch. By means of the ratchets any desired strain can be given the saw, which is guaranteed to be perfectly even at all points of the stroke. The upright tubular shaft is of wrought iron, turned true both outside and inside, and to it are attached all the working parts above the table.

The 'parlour' saw, by the same maker, is for delicate work. The saw is stretched between two wooden spring beams, and is vibrated by means of a bell-crank lever, carrying two rollers, running on a wheel with a serpentine periphery, which can be run by the foot to give the saw 1,200 motions per minute.

In Walker Brothers' improved scroll saw the straining arrangement is intended to produce an even tension at all parts of the stroke, both upwards and downwards, by the improved form of the spring and friction link; the former can be readily slackened and thrown out of work by a screw in front of the machine, and a blower is provided for removing the sawdust from the table.

The reporter, W. H. Barlow, F.R.S., remarks that the display of American saws, axes, and other wood-cutting instruments is one of the finest in Machinery Hall, and at the same time it is one of the most ornamental, as the highly-polished saws, some of great size, tastefully arranged on large screens, make a glittering show. The difference in the form of the American and English tools, especially in the teeth of the saws, is very marked.

He expresses his regret that Sheffield did not send any circular saws, and then says that the display of circular saws made by Canadians was splendid, 'and, as far as could be inferred from an examination, the quality was all that could be desired.'

One of the most tedious and laborious processes in wood-working is undoubtedly the sawing through any great length or thickness of timber, and certainly a carpenter could not but begrudge the time and labour spent on such an operation, after seeing the ease with which a saw-bench made by Messrs. Furness and Co., of Liverpool, can saw through any length of timber with surprising celerity. It will, in fact, cut battens, deals, or planks up to 60 ft. per minute.

The machine frame is one strong casting, thus saving all jar and tendency to shake to pieces. The saw is 42 in. in diameter and carried on a strong steel spindle, running in improved gun-metal bearings, and may be driven by a pulley fixed either between

the bearings or by a fast and loose pulley outside. The top force of the frame is planed and well got up, and is further fitted with a strong guide fence, with lever and pressure rollers to keep the timber up to the fence. The drag or feed motion is very ingenious, the feed being effected by the coiling up of a drag rope upon a drum to the left hand of the machine; the motion of the drum being made automatic by a suitable belt motion, taken from a pulley on the saw spindle. The pressure of the guide roller is put on by a lever arm and hanging weight. Two carriages can be fitted to this machine to run on rails—one at either end—to carry logs or long scantlings.

This firm also manufactures a combination for tonguing, grooving, and cross-cutting, as well as sawing. It may be used for plain sawing, being provided with a very convenient fence, which is also adjustable to any angle for bevel cutting.

This fence may also be immediately removed and replaced by a cross-cutting slide, in which the timber may be placed and cut perfectly square.

The saw itself may also be easily removed, and a head, carrying revolving cutters, substituted for it, so that tonguing and grooving may, with little trouble, be thus performed on the same machine. A suitable slide is also affixed to the side of the machine, so that mortising and boring may be effected by a tool carried on the main spindle. A great variety of work may be thus performed with a very compact and cheap machine, combining, in fact, two machines, without impairing the efficiency of either. It will, therefore, be well adapted for small establishments.

A tenoning machine, mostly in use by joiners and builders, is fitted with sash scribing apparatus and a trenching cutter-head. It is a very simple and compact machine, and the quality of the work is really excellent.

Another contrivance, rather more complicated in construction and well worthy of notice, is Messrs. Furness and Co.'s four-cutter planing and moulding machine. The solidity of construction—viz. the casting of frames and tables as far as possible in one piece—is also noticeable in this as in the previous machines, the frame being in one piece, and the table in another single casting. The four-cutter heads enable the timber to be worked on all four sides at once, allowing a feed of from 10 to 20 ft. per minute, of perfectly finished moulding, to be produced with ease.

The timber is fed through the machine by four calender rollers, of which the upper ones are pressed to their work by means of weights, so that any slight variation of thickness in the timber is of no moment. As a further guard against vibration and wear, the spindle runs in a conical bearing. Any wear may thus be taken up with ease and certainty. Practical convenience in the transference and setting of cutters has been well considered in this machine, and there is no point that more materially affects the comfort and rapidity of handling to the workman. This has been specially attended to in two arrangements:—First, that the cutter-heads may be removed entirely for a change of work, without displacing the cutters. This is a great convenience and saving in time, since separate heads may be used solely for planing and different sections of mouldings, with the tools already set. The change of head is an easy and simple operation.

The second practical convenience lies in the fact of the cutter-heads being placed outside the machine, by which arrangement the setting of the cutters may be effected with ease.

Messrs. Worn and Lewis have introduced some very excellent labour-saving machines, one of the most interesting being a combination of band and circular saw, for being worked either by hand or by power. It is well known that a frequent cause of the saw breaking is its becoming buckled on heating. To avoid this a third pulley is introduced, which gives an increased distance between one and the other, and so allows the saw time to cool. The G-shaped frame affords plenty of space for large work to pass between the saw and the frame. The pulleys have no flanges, thus avoiding a further cause of breakage, as will be explained in connection with another machine; and the saw is kept from slipping off by being packed close to its work with adjustable blocks. The table is made to cant, as usual, being clamped in position by a nut screwed up against a quadrant underneath.

The circular saw has a rising and falling spindle to allow of rebating and tenoning, the bearings being raised and lowered by a hand-wheel under the table. The end of the spindle carries an auger, by which any sized hole, up to 2 in., may be bored, and a rising and falling table is provided to hold the work. Fitted to the bench is a canting fence, for feathering. The circular saw may be worked by one man only, as it is provided with a self-acting rope feed. The rope, attached to a piece of board which draws the work along, is wound up on a pulley underneath the bench, made to revolve by a worm on the first or driving shaft. The second shaft, in gear with the first, at an increased speed, carries the circular saw and also the third pulley which works the band saw. When power is employed, the band saw, circular saw, and

boring apparatus can all be worked at the same time without interfering with each other, and when the machine is turned by hand one man can cut up to 6 in. deep with the band saw, and 5 in. with the circular.

In the improved endless band saw not only has every precaution been taken to prevent the saw from breaking, but every possible safeguard seems also to have been added in case it should break, while the diminution of length due to splicing is also provided for. The bearing of the upper pulley is made elastic by the addition of the firm's patented double-tension spring and weight. The bearing works in a V-slide at the top of the standard, the tension being maintained by the weight and lever, and the fulcrum of this lever is carried by another adjustable slide, supported by a strong spiral spring, compressed or allowed to expand by means of a screw and hand-wheel. With this compensating arrangement a saw may be considerably reduced in circumference by successive bearings, and yet serve for the same machine. Chance of breakage is also much diminished by means of three separate packings, one directly above the work, one directly below, and a third on the up-throw, which last, being about 2 ft. in length, gives considerable steadiness to the saw, and also serves as a guard to avoid accidents. In addition to the packing blocks steel rollers are added, both above and below the table, which support the back of the saw, to prevent the jumping which is so apt to occur in cutting hard wood. As these two rollers are capable of being shifted up to the back of the saw, as a groove is worn in them, they also prevent a groove from being worn by the saw in the flange of the pulleys, a groove which is liable to catch the saw and snap it. If the saw, in spite of all these precautions, should happen to break, the top would be caught by a curved guard which protects the head of the operator, while the rest would be held in the long side guide before mentioned, so that no accident would be caused. The bearings of the lower pulley are raised in standards bolted to the bed-plate, thus saving the necessity of cutting into the floor to allow the pulley to clear. The table is large, and may be canted to any angle; and the upper guide may be adjusted to suit any thickness of stuff. The striking gear is brought under it in a convenient position, so that the machine can even be started by the operator's knee.

Wood-cutting by a new Method.—A novel method of cutting wood has recently been invented in the United States. It consists in substituting for the saws ordinarily employed a platinum wire, which is fixed and worked in the same manner as the saws used for fret-work. Through this wire a current of electricity is passed to maintain it at a red heat. When the wire in this state is worked backward and forward in the same manner as a saw, it penetrates even the hardest wood with astonishing rapidity. The instrument may be used to saw out boards or forms of the most varied nature from balks of the largest scantling, the wire lending itself to changes of direction far more readily than the band saw does. It is true that the action of the heated wire is to slightly carbonise the surfaces of the wood; but the trifling loss thus incurred is not greater than that due to the ordinary saw cut.

General Joiners.—The machines bearing this name are so well known in the building trade that a short notice only is required of them.

The machine has been designed to meet the objections which are urged with more or less justice against the class of machines known as 'General or Universal Joiners,' and it is guaranteed to be capable of performing the whole of the following operations in a thoroughly satisfactory manner, viz.:—

Sawing.—It will work saws up to 24 inches in diameter, and will deep 9-inch deals.

Cross-cutting.—It will cross-cut stuff of any length up to 4 inches thick.

Planing.—It will plane, groove, tongue, edge, thickness, and bead, at one operation, boards up to 9 inches wide.

Moulding.—It will stick single or double mouldings of any pattern, worked on all four sides, up to 9 inches wide.

Circular Mouldings.—It will cut circular mouldings of any pattern up to 3 inches wide.

Grooving.—It will cut grooves from $\frac{1}{8}$ inch to $1\frac{1}{2}$ inches wide.

Tenoning.—It will cut single or double tenons, and scribe the shoulders at one operation.

Mortising.—It will make mortises from $\frac{1}{8}$ inch to $1\frac{1}{2}$ inch wide, of any length, in any kind of wood.

Boring.—It will bore holes from $\frac{1}{8}$ inch to 2 inches in diameter.

The saw spindle is entirely distinct from those which carry the planing and moulding cutters, and hence the operations of sawing and planing or moulding can be carried on simultaneously or separately as at two distinct machines.

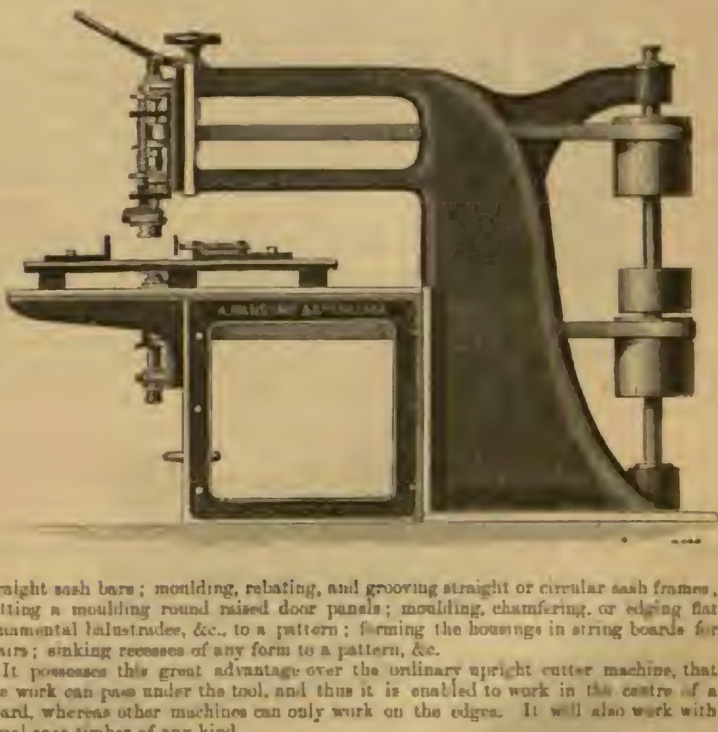
The saw table rises and falls for grooving, rebating, &c., and is fitted with an improved fence, which can be set at any required angle, and is hinged, so that it can be

turned over at the end of the table when it is required to use the saw for cross-cutting.

The planing and moulding apparatus is permanent, and is thus always ready for work. The top and bottom cutter-block spindles are supported in bearings on each side, which ensures great steadiness, and enables the machine to turn out very clean work. The wood being planed or moulded, is fed through by a pair of revolving feed rollers, both of which are driven; by which means a greatly increased propelling power is obtained. The top feed roller rises and falls to suit the irregularities in a rough board, and at the same time it always exerts its full feeding power. The rate of feed can be varied according to the nature of the wood being operated on.

Universal Moulding, Shaping, and Recessing Machine.—This machine, *fig.* 2567, is capable of application to a vast variety of purposes, among which may be reckoned—cutting circular or twisted mouldings of any form; sticking circular and

2567



straight sash bars; moulding, rebating, and grooving straight or circular sash frames, cutting a moulding round raised door panels; moulding, chamfering, or edging flat ornamental balustrades, &c., to a pattern; forming the housings in string boards for stairs; sinking recesses of any form to a pattern, &c.

It possesses this great advantage over the ordinary upright cutter machine, that the work can pass under the tool, and thus it is enabled to work in the centre of a board, whereas other machines can only work on the edges. It will also work with equal ease timber of any kind.

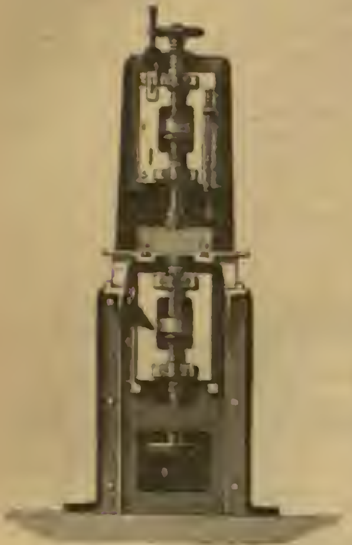
The framing is very strong, and the cutter overhangs a great distance, which allows of the work being freely moved about in any direction upon the table. The fore part of the framing is made as narrow as possible, to allow of cutting a moulding round the face of a circular sash frame, or other similar work.

The top cutter-spindle works in a carriage, which can be raised or lowered by a handle, as shown in the woodcut; this slide is provided with an adjustable stop for regulating the depth of the cut, and its weight is counterbalanced by a spring, which makes it very sensitive and easy to work. A back slide is added, worked by a screw and hand wheel, by which the vertical range of the cutter can be very much increased. The end of the cutter spindle is screwed on the outside to take a small adze block, to which moulding irons of any pattern can be attached, and it is bored up to receive cutters for chasing, recessing, or boring. A small false end is supplied to fit the cutter spindle, furnished with a long slot, for taking a small cutter for working mouldings round very sharp internal sweeps.

This machine is usually provided with a second cutter spindle, as shown in *fig.* 2568,

which works below the table, but can be brought up above it by a hand wheel, and is very useful for some descriptions of work.

2568



Patent Combined Planing and Moulding Machine (small size).—As fully 90 per cent. of the mouldings in general use are under 4 inches wide, it is clear that in any mill where there is more work than one moulding machine can turn out, it is economy to have one at least which is specially adapted for light work.

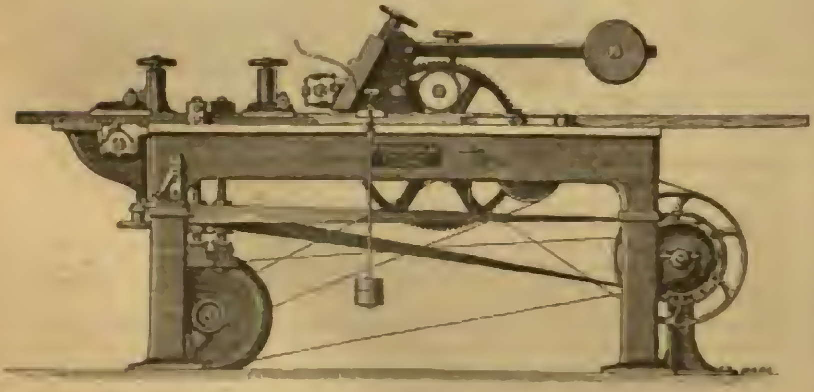
In such cases the small machine represented (*fig.* 2569) is strongly recommended, having been designed expressly for running light mouldings with great speed and high finish.

In its general construction it closely resembles the larger machines, but all the cutter spindles being lighter, they can be driven at a proportionately higher speed, thus admitting of the wood being passed more rapidly through. The feed, which consists of a single pair of rollers, both of which are driven, can be varied from 20 to 40 feet a minute, the work produced even at the highest speed being very clean and sharp.

Band Saw Machines with Self-acting Canting Tables.—These machines differ from those last described only in the addition of a self-acting canting motion to the table, by means of which any sweeps of varying bevel can be cut with the greatest ease.

The table is fitted with an index, which works upon a graduated quadrant fixed to the framing of the machine, and the canting motion is provided with four different speeds, which are used according to circumstances, *fig.* 2570.

2569



When the self-acting canting motion is used, the man working the machine subdivides the line of the saw cut, marked upon the top of the piece to be sawn, into certain equal parts, and so regulates the rate at which he feeds it up, that the saw arrives at each of these marks exactly as the index points to the corresponding mark upon the graduated scale.

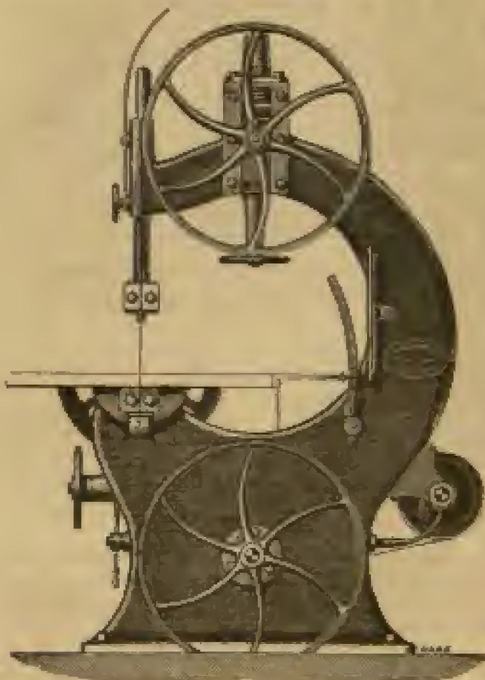
The self-acting arrangement is readily disconnected when not required, and the machine can be used as an ordinary band saw, with the table set either level or at an angle.

Another similar machine is intended for sawing deals or flitches of any description of timber into boards of any required thickness, and is particularly recommended in

cases where but few cuts are required in each piece. For sawing deals or flitches with only one or two cuts, it is more advantageous than either a deal frame or a circular saw bench, as it cuts much faster than the former, and wastes much less wood, and requires considerably less power than the latter. It will work saws up to 3 inches wide, and will cut flitches up to 20 inches deep and 6 inches thick.

The timber is brought forward at rates varying from 6 to 24 feet a minute by a new smooth roller feed. This consists of four vertical rollers, all of which are driven,

2570



thus possessing a great propelling power; and as the rollers are all perfectly smooth they do not indent the wood. The two inner feed rollers work between the fence bars, and are so arranged as to allow the piece being sawn to lightly touch the bars, while at the same time the rollers are exerting their full feeding power. The fence bars and inner feed rollers are attached to the same bracket, which can be readily set nearer or farther from the saw to regulate the thickness of the boards to be cut, by turning a handle at the side of the table, and the outer rollers open out so as to admit deals, planks, or flitches of all thicknesses, from $1\frac{1}{2}$ to 6 inches.

Mortising Machines.—Machines for mortising wood, although offering a great variety in design and mechanical combinations, may be classified under the three following heads:—

1. Machines which work with a chisel, having a vertical reciprocating action.

2. Machines in which the mortise is formed by a revolving traversing auger or bit, so constructed as to cut on the side as well as on the end; and,

3. Machines constructed to work with a square hollow chisel, having an auger working inside it.

Mortising machines, with reciprocating chisels, are undoubtedly the kind which are in most general use, and embrace all those which are made for hand or foot power; this principle being applicable alike to large or small machines, or for any description of timber. The disadvantages of this system are, that when mortising hard wood it is necessary to bore a hole for the chisel to enter, and as the chisels in ordinary use jam the chips into a compact mass, a third operation is needed to clear the mortise of the chips after it has been slotted out by the chisel.

Soft wood can be mortised by a reciprocating chisel without previous boring, provided the machine is so arranged that the chisel can be brought gradually down deeper and deeper into the wood after each stroke; and some machines are even made, for joiner's work, in which the chisel enters at once to its full depth at the first stroke. This is, however, very objectionable, as the chisel plunging at once 2 or 3 inches deep into the wood, causes a great jar, which throws an undue strain on the machine, and frequently bends or breaks the tool, which, moreover, having to be made very thick in order to stand such a heavy blow, wedges the chips so tight in the mortise as to make it very troublesome to remove them.

In the improved mortising machines working with reciprocating chisels, the above objections to this system have been greatly overcome by attaching to such as are used for hard wood a boring apparatus, which is fixed to the main standard of the machine in such a position that the centre of the auger is always exactly in a line with the centre of the chisel, so that the piece after being bored is merely shifted along sideways to the chisel, thus saving the extra handling and separate adjustment which would be necessitated if the boring were done at a separate machine. The difficulty of the chips jamming into a mass in the mortise is entirely obviated by the use of a new form of chisel, which is so constructed as effectually to draw each chip as it is cut. These chisels, although considerably more expensive than those in ordinary use, effect a great economy, as in many cases where reciprocating mortising machines are in use it takes almost as long to knock out the core as it does to cut the mortise.

The principle of cutting mortises with a revolving auger or bit has the advantage of being readily applied to almost any other machine having a spindle revolving at a sufficient speed, but as from the revolving action of the bit the ends of the mortises are left round, a separate operation is needed to square them out. There are, however, many classes of work in which it is no disadvantage to have the ends of the mortise left round, as in posts for fencing, and many of the mortises which occur in cabinet and pianoforte work, and for such purposes this system is recommended in preference to any other. It is also the best principle to adopt for very small mortises, especially in hard wood, as a reciprocating chisel of less than $\frac{5}{16}$ inch wide is very liable to get bent in work, and requires the mortise to be of considerable length for the tool to work down gradually to the full depth, whereas a revolving bit can make the shortest possible mortises, care being taken when using small bits not to put them so deep into cut as to cause them to spring, as in such case they will not make good work.

Figs. 2571 and 2572 show two views of a new and improved machine, capable of mortising any description of timber, and adapted for the heaviest kinds of work. It is particularly recommended for railway waggon and carriage works, the larger of the two sizes being capable of cutting a 2-inch mortise through a piece of timber 12 in. thick.

The carriage in which the mortising spindle works is fitted with a self-acting motion for bringing it gradually down, so as to enable the chisel to work deeper and deeper into the wood at each stroke, and it has a rapid ascending motion by which the chisel is drawn up clear of the wood when the mortise is completed. The chisel is instantaneously reversed by a self-acting motion, which can only operate when the tool is clear of the work, thus preventing the possibility of its turning in the wood and so spoiling the mortise.

The table on which the timber rests can be readily raised or lowered to suit for thicker or thinner stuff, and it is supported immediately under the chisel by a very strong screw which takes the thrust of the cut. The table is fitted with cross slides, by which the piece can be readily adjusted into the required position, and the top slide is fitted with a rack and pinion for traversing the timber easily under the chisel.

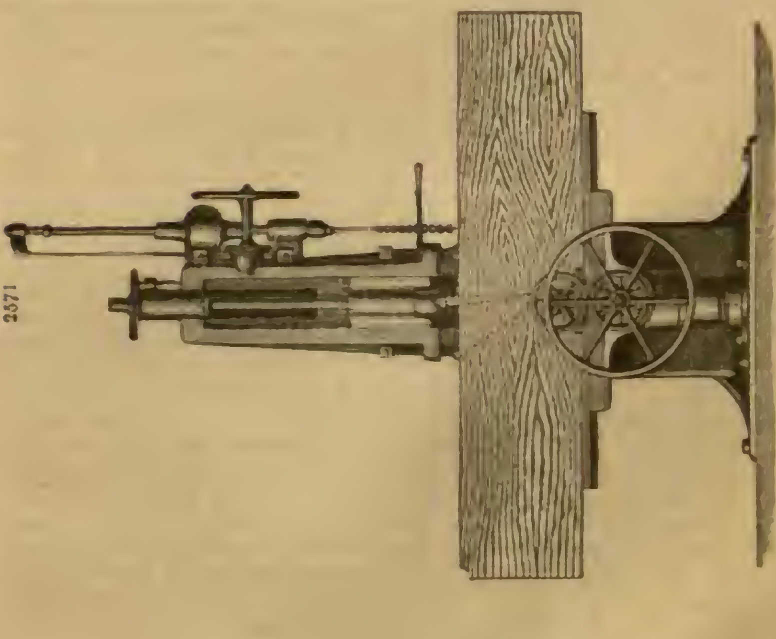
These machines are all fitted with improved self-clearing mortise chisels, which draw the chips as they are cut, thus preventing them from jamming into a mass, as in the case where the ordinary chisels are employed.

The boring apparatus is fixed in such a position that the centre of the auger is always exactly in line with the centre of the chisel, so that the piece, after being bored, merely requires to be shifted laterally to bring it under the chisel. The boring spindle has a vertical range to enable the augers to clear through the largest piece of timber which the machine will take in, and it can be used as a separate boring machine when not required for mortising.

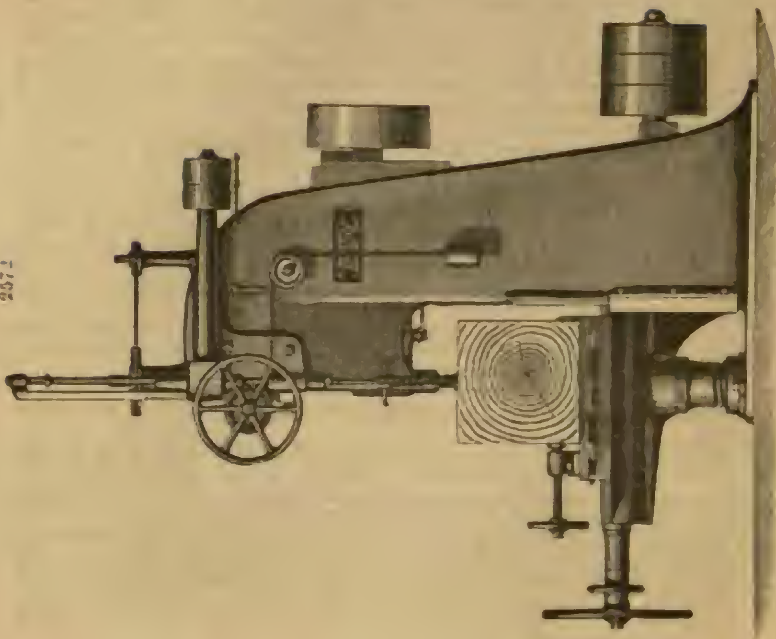
The handles which govern the various motions are all placed conveniently for the operator, and the machine is driven from a countershaft placed on the floor.

Boring Machines.—The operation of boring wood by machinery is so exceedingly simple that it would at first sight appear hardly necessary to devote any space to the consideration of this subject; but although, where the piece to be bored is

2571



2572



sufficiently light to be readily handled and brought into the required position under the auger, the machine need only consist of a spindle running at a suitable speed, with a ready means for bringing the auger into contact with the wood, yet where heavy timber has to be bored it becomes necessary to construct the machine in such a manner that the auger can be adjusted and brought into any required position instead of moving the piece to the auger. The difficulty of accurately adjusting heavy pieces of timber under an auger in machines in which the boring spindle is stationary is so great, that in some cases it is doubtful whether it is not almost as cheap to bore them by hand; but where the auger can be readily adjusted to any desired spot on the surface of the timber, a very great economy of time and labour is effected.

As it is impossible, without incurring great expense, to construct a machine in which the auger shall travel throughout the whole length of a long piece of timber, it is usual to provide boring machines required for heavy work with a series of turned rollers, or a strong truck running on rails, on which the timber is laid to facilitate its movement endwise. This, however, although lessening considerably the labour of shifting the piece, does not overcome the difficulty of adjusting it accurately under the auger, and when it is considered that the time actually occupied in boring a hole of the largest size by a machine is only a few seconds, it will at once be apparent that any provision which allows of the timber being brought rapidly into position under the auger will effect an important saving in time.

A combined vertical and horizontal boring machine is shown, *figs.* 2573 and 2574. This machine is intended for railway carriage and waggon work, and for other heavy boring.

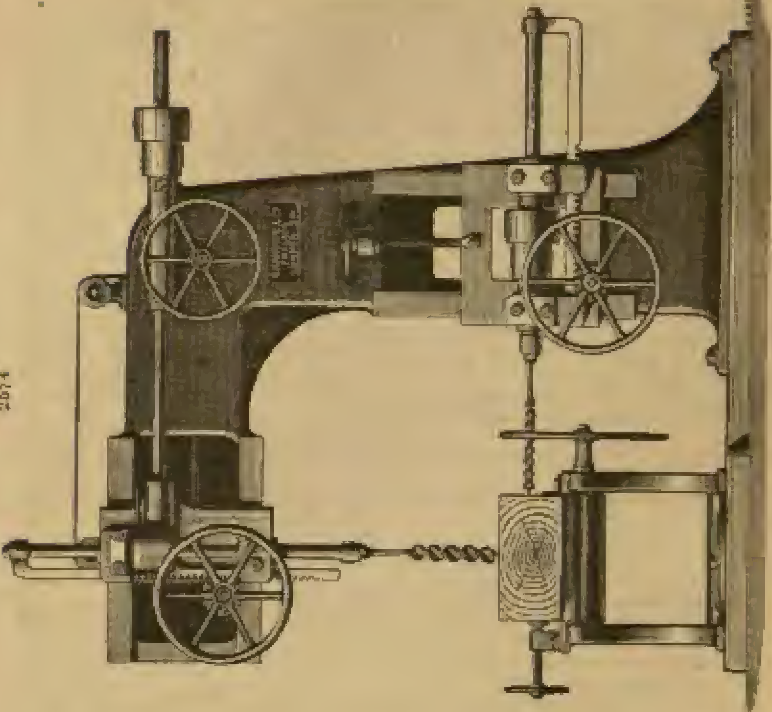
It is furnished with a horizontal as well as a vertical spindle, which enables it to bore holes in both directions without the timber requiring to be turned on edge. The machine will bore holes up to 3 in. in diameter, and both the spindles have sufficient range to enable the augers to clear through a piece of timber 14 in. square.

Each auger can be readily adjusted into any required position over the surface of the timber, which, therefore, only requires to travel in the direction of its length. The table is fitted with a series of turned rollers connected by gear-wheels, so arranged that all the rollers are made to revolve simultaneously in the same direction by turning a hand-wheel, and the timber resting upon them is by this means readily moved and easily adjusted.

The table is made to pivot on a centre-pin for boring diagonal holes at any angle to the surface of the wood.

All the hand-wheels which govern the boring spindles, as well as the one which travels the timber, are placed within easy reach of the operator, who, standing by the side of the horizontal boring spindle, is in the most convenient position for seeing and adjusting the timber and augers.

CASK MAKING. (Vol. i. p. 744.)—Since the article referred to was written, several new machines have been introduced, all of them tending to facilitate the process of making casks by machinery there described. Amongst the most remarkable are the works of the Messrs. HANSOME and Co., of the Stanley Works, King's Road, Chelsea. Their cask making is very ingenious. The whole process is conducted within a single shed, where by successive machines, attended either by boys or by unskilled workmen, the staves are cut out, shaped, and fitted; the hoops punched, splayed, and bent; the heads planed, ovalled, and bevelled, and the several parts, first roughly put together by hand labour, compressed and united with the greatest possible firmness. Every portion of each cask being fitted to the rest with mathematical accuracy, the completed work is far better, stronger, and tighter than anything which can be turned out by the most skilled hand labour, and the saving in cost is even more remarkable than the improvement in quality. According to a calculation supplied by the firm, the present cost of making 600 hogsheads a week by hand labour would be 141*l*. 5*s*., or 4*s*. 8½*d*. each, while the cost of making them by machinery would be 55*l*., or 1*s*. 10*d*. each. In this estimate no allowance is made for coals, oil, or wear and tear of plant, because the total amount of these expenses would be less than that of the truss hoops and other matters required in a hand cooperage of the size supposed. The machine plant for 600 hogsheads a week would cost 3,500*l*., so that the stated weekly saving of 85*l*. 5*s*. in labour would afford a very large return upon the outlay, even without considering the superior quality of the casks and the avoidance of the breakage and waste of wood which occur in hand manufacture. The workmen who are employed are none of them skilled coopers, and many of them work well when they have had only a week's practice with the machines; but the casks which they make, when subjected to the severest tests, are declared to be in every respect entirely satisfactory.



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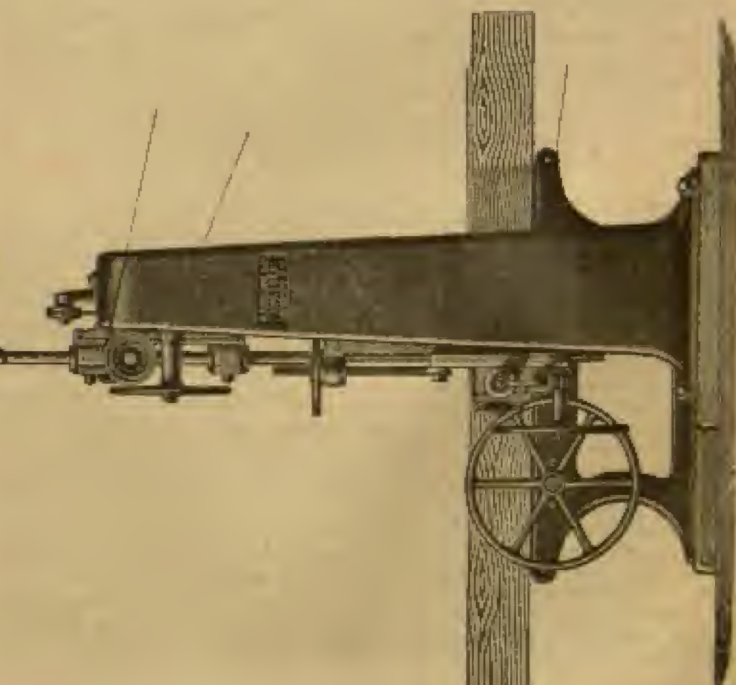


2573

Messrs. E. and B. Holmes, of Buffalo, N.Y., exhibited at the Philadelphia Exhibition a series of machines for making tight and slack barrels of different sizes. The first operation consists of sawing off the staves to the required length, by means of two circular saws set on one spindle, with the proper interval between them; the staves are then passed through a machine which dresses both sides of them simultaneously. The jointing of the staves and cutting them to the requisite curve is performed by holding the stave against the side of a revolving concave wheel furnished with a radial cutter. The staves are then placed in a setting-up frame, which retains one end of the staves in position; the barrel is then conveyed to a windlass machine, which draws the other end of the staves together by means of a wire rope passed round them, and a hoop is then dropped over them. The barrel is then placed over a stove and heated inside, and then the hoops are forced on by a dressing machine. The next operation is performed on a working-off machine, where the exterior of the barrel is smoothed and the grooves and bevels for the reception of the heads are cut. The heads are jointed on a wheel and planed on one side only, and are then turned and chamfered. A machine is also shown for cutting shingles or barrel-heads, and for punching and riveting iron hoops at one operation. Wooden hoops are still made by hand. The set of machines thus briefly described is for making tight barrels for containing liquids, and will turn out 500 barrels per day with one man in charge of each tool. The tools for constructing slack barrels for solids and small kegs are upon the same principle, with modified details.

Rule Making.—Although this is only incidentally connected with wood-working machinery, yet it belongs so essentially to this branch of industry, that we are glad to introduce a graphic description of the processes adopted at the works of the Messrs. John Rabone and Son, of Birmingham, given some time since in *Iron*:—

The various processes of rule making are exceedingly interesting. The first place to visit is the saw mill. Here is a large stock of boxwood. The trees are first sawn into strips of the requisite thickness, and are then thoroughly seasoned. When sufficiently dried the strips are cut again into the widths required for future use. They are then sorted out according to the quality of the rules to be made.

The little strips of box are next subjected to the two processes of cutting the ends and drilling. First the quadrants are cut out to receive the joints, then the holes for the pins are drilled, then slits to receive the plates of the joint, and the recesses made for the brass tips at the ends to be fixed. By the use of admirably constructed machinery, the utmost accuracy as to length, cut, fit, and shape is secured, and the work is done with great rapidity. After the woodwork is all prepared, each rule is hinged and jointed, the holes for putting in the pins are drilled, and by an ingenious process are made so as to open straight by a machine which secures the utmost nicety of fit, and when this is done the rule is ready for filing off. A very pretty little machine makes the pins. A coil of brass wire of the required thickness is placed round a revolving drum, and the end passed through the machine, by which the pin is made. One little self-acting machine makes 800 pins per minute.

One of the most interesting machines is one for producing the 'registered Vulcan joint.' This is, in fact, an adaptation to rule making of the famous copying machine of James Watt. The device he invented for making or rather carving statues, &c., is here applied for the purpose of making a rule joint. It is almost automatic; any pattern can be produced, and it is so simple in action as to be easily and readily worked by a girl. The sides of the rule are fixed in a cramp, and the cutting tool moves about with apparently intelligent and sentient faculties, now cutting here, now cutting there, as the pattern of the joint requires, and the work is finished with the utmost accuracy and precision. Nothing can be neater, cleaner, or more workmanlike in its result than the 'Vulcan joint' thus produced. The most important results of the application of machinery to rule making are the unvarying accuracy with which the work is done, by which all the parts are made interchangeable, and the consequent cheapness of the articles produced.

The wood being prepared, the process of joint making follows. There are two kinds of joints—the large joints and the small ones. For the large joints long slips of brass rolled to the required thickness, or rather thinness, are used. These are rapidly passed under an adjustable steam press, which is quite unique in its action. At each movement of the press a piece of brass of the form of the joint required is cut out, and drops into a receptacle beneath. This is repeated until the whole of the slip is cut. A great saving of metal is effected by the use of the press, as compared with the old process of hand stamping. Each joint has to go through from eight to ten processes before it is completed for use. A very ingenious self-acting machine is also used for countersinking the holes in the joint.

The small joints are also made by self-acting machinery, and have to pass through a large number of processes. The large joints of the rules made in this manufactory are different from those used by other makers. Instead of, as is usual in the trade,

the joint being composed of a thin centre piece, or middle plate of metal, between two thicker pieces on the outside, and the wood being cut away and thereby weakened to admit the centre plate, Messrs. Rabone's joints are composed of a thick centre plate between two thinner outside ones; the wood is not reduced to admit of its insertion, and the great advantage of these joints is that in all rules thus made the joints are the strongest and least destructible parts of the rule. Thus accuracy of fit, interchangeableness of parts, strength, and durability are secured by the very means which also secure cheapness of production.

The wood having been prepared, the joints made and fixed, the rules are then subjected to a process technically called 'doing off.' That is, the flat parts are filed and smoothed; the hinges, joints, and tips being completed by the machines before they are fixed.

The marking and numbering are also interesting operations. In small quantities these processes are still done by hand; and it is pleasant to see the speed and accuracy with which skilled workmen execute this important and delicate bit of handicraft. Their speed and accuracy are, however, greatly surpassed by the marking and dividing machines. The Messrs. Rabone have three classes of these machines in operation, and the divisions into inches, eighths, and sixteenths, are made with an exactitude and precision which are almost incredible. By the simplest motion of one part of the machine the inch is divided into eighths or sixteenths at the will of the worker. The numbers are also impressed with similar speed and exactness. The machines are small, and worked with the greatest ease.

When the rule is made it has to be polished, the lines blackened, and marked out, and then varnished. It is then ready for the market, and is the article which is known to all mankind. All kinds of rules are manufactured by Messrs. Rabone and Son, from the long broad yard measure to the pretty small ivory four-foulding foot rule, which you can carry without inconvenience in your waistcoat pocket.

A fair idea of the nature of rule making may be formed from the fact that every rule, in preparing the wood, making the joints and ends, and in completing it for use, has to go through from forty to fifty different machines, and from sixty to one hundred distinct operations, according to the style of the rule.

WOOD PRESERVING. (Vol. iii. p. 1155.) It is found that woods of slow formation are far more durable than such as are grown rapidly. The woody fibre itself is but little affected by the action of air or water, but the albumen and other bodies existing in the sap are very liable to decompose. Therefore the heart wood of trees, as being the most dense, is less liable to change, or to be attacked by insects, than the other parts. Resinous woods are also more durable than such as are non-resinous. Young sappy wood is liable to a rapid change, and is exceedingly attractive to insects.

As a rule, it appears that those woods are the most durable which have been grown under a full exposure to sunshine, and with the free influence of air. Woods grown in close and gloomy situations are liable to attacks by insects and fungi. Of the latter the more remarkable are the *Telephora domestica*, the *Boletus destructor*, and the *Corolina vastator*. The acetate of iron is said to be a remedy for these fungus growths.

By causing the root end of a freshly felled tree to stand in a solution of sulphate of iron, bichloride of mercury, sulphate of copper, &c., these bodies are sucked up into the wood, and replace the sap. This method seems to be the one which gives the most promising results, and wood treated in this manner with sulphate of iron becomes extremely durable.

Wood Staining. *Yellow or Orange Stains.*—A fine orange tone is given to oak by rubbing it with the following mixture:—3 ounces of tallow, ¾ ounce of wax, and 1 pint of oil of turpentine, melted together. This must be applied until the wood acquires a dull yellow polish. After resting an hour a coating of thin French polish is to be applied, and the above mixture is to be again used, and repeated until the proper tone is produced.

Brown Stains.—In all cases the natural colours of wood may be darkened by the use of either the alkalis or caustic earths. According to the strength of the solutions employed, so is the intensity of the colour produced. The resulting colour is to be secured by varnish or polish, the latter being preferable for fine work.

Black Stains.—A German trade circular describes two kinds of black stain for wood:—(1) The ordinary black stain for different kinds of wood; (2) the black ebony stain for certain woods which approach nearest to ebony in hardness and weight. The ordinary black wood stain is obtained by boiling together blue Brazil wood, powdered gall-apples, and alum, in rain or river water, until it becomes black. This liquid is then filtered through a fine organzine, and the objects painted with a new brush before the decoction has cooled, and this repeated until the wood appears of a fine black colour. It is then coated with the following liquid:—A mixture of

iron filings, vitriol, and vinegar is heated (without boiling), and left a few days to settle. If the wood is black enough, yet for the sake of durability it must be coated with a solution of alum and nitric acid, mixed with a little verdigris: then a decoction of gall-apples and logwood dyes are used to give it a deep black. A decoction may be made of brown Brazil wood with alum in rain water, without gall-apples: the wood is left standing in it for some days in a moderately warm place, and to it merely iron filings in strong vinegar are added, and both are boiled with the wood over a gentle fire. For this purpose soft pear wood is chosen, which is preferable to all others for black staining. For the fine black ebony stain, apple, pear, and hazel wood are recommended in preference; especially when these kinds of wood have no projecting veins, they may be successfully coated with black stain, and are then most complete imitations of the natural ebony. For this compound 14 ozs. of gall-apples, $8\frac{1}{2}$ ozs. of rasped logwood, $1\frac{3}{4}$ oz. of vitriol, and $1\frac{3}{4}$ oz. of distilled verdigris are boiled together with water in a well-glazed pot, the decoction filtered while it is warm, and the wood coated with repeated hot layers of it. For a second coating, a mixture of $3\frac{1}{2}$ ozs. of pure iron filings, dissolved in $\frac{3}{4}$ of a litre of strong wine vinegar, is warmed, and when cool the wood already blackened is coated two or three times with it, allowing each coat to dry between. For articles which are to be thoroughly saturated, a mixture of $1\frac{3}{4}$ oz. of sal ammoniac, with a sufficient quantity of steel filings, is to be placed in a suitable vessel, strong vinegar poured upon it, and left for fourteen days in a gently heated oven. A strong lye is now put into a good pot, to which is added coarsely bruised gall-apples and blue Brazil shavings, and exposed for the same time as the former to the gentle heat of an oven, which will then yield a good liquid. The woods are now laid in the first-named stain, boiled for a few hours, and left in for three days longer; they are then placed in the second stain, and treated as in the first. If the articles are not then thoroughly saturated, they may be once more placed in the first bath, and then in the second.

Wood and Timber Imports.—*Wood and Timber imported in 1876*:—

	Fir, hewn	Oak, hewn	Teak, hewn	Unenumerated
	Loads	Loads	Loads	Loads
From Russia	316,350	3,796	—	7,567
" Sweden	297,653	—	—	2,728
" Norway	310,012	—	—	3,562
" Austrian Territories . .	—	1,416	—	—
" Germany	203,624	50,339	—	3,060
" France	221,764	4,854	—	—
" United States of America .	201,769	7,854	—	2,045
" British North America .	349,340	67,460	—	62,045
" British India	—	—	34,416	—
" Straits Settlements . .	—	—	810	—
" British West Indies . .	—	—	—	539
" British Guiana . . .	—	—	—	8,256
" other Countries . . .	4,338	227	40	—
	1,904,870	135,951	35,266	93,289

	Sawn or split, planed or dressed Fir	Sawn or split, planed or dressed Unenumerated	Staves
	Loads	Loads	Loads
From Russia	902,373	103,275	10,901
" Sweden	1,054,450	132,868	11,978
" Norway	398,510	65,972	20,385
" Germany	66,579	9,217	34,718
" Holland	—	16,485	—
" United States of America .	217,635	6,656	11,070
" British North America . .	1,113,269	6,655	10,504
" British India	—	6,121	—
" Austrian Territories . .	—	—	10,236
" other Countries . . .	6,022	11,169	1,422
	3,750,775	355,417	120,216

	Tons	Value
Mahogany	32,461	£446,353
Unenumerated	43,202	422,306
House frames, &c.	—	71,709

Value of Woods.

Hewn Fir	£4,664,619
" Oak	822,319
" Teak	416,946
Unenumerated	393,732
Sawn or split, &c., Fir	10,811,693
" " Unenumerated . .	727,913
Staves	656,763

In 1867 we imported of hewn timber, 2,079,613 loads; of sawn or split timber, 4,572,748 loads; of staves, 110,070 loads; and of mahogany, 63,169 tons.

WOOL. Although the term wool is understood generally to mean the fibre produced by the sheep, such being its meaning in fact in this article, yet almost every animal with hair of any length also grows to some extent a quantity of wool next the skin.

It must be understood that although often somewhat alike, hair and wool are entirely distinct in construction, most of the characteristic features which give wool its commercial value being absent in the construction of hair.

When examined with the aid of the microscope, hair is seen to have a tubular appearance, having a hollow or medullary in the centre of the fibre, the outer surface being smooth and slippery. This smoothness renders hair unavailable for many of the purposes for which wool is used—as, for instance, in the manufacture of cloth, where the fibre is required to be milled, felted, or matted together.

A few years ago the manufacture of hair into anything like a respectable cloth seemed almost hopeless; but such have been the improvements in machinery of late years that almost any kind of hair can be made into a web of some sort, even such an unpromising article as calf hair, concerning goods made from which a lively discussion has recently taken place between the Customs officials of the United States and this country.

Among the immense variety of hair, those which come nearest to wool in their nature, speaking commercially, are alpaca, mohair, and camels' hair, all of which are used in the worsted trade, the consumption of the latter having largely increased during the last year or two.

The fibre of wool presents an entirely different appearance from that of hair. Its form is not round, but irregular; nor has it the hollow or medullary in the centre of the fibre as in hair. It is curly and elastic, and when examined under the microscope each fibre is found to be covered with small imbrications or scales, which vary in number and shape according to the description and quality of the wool. These render it peculiarly liable to felt or mat together in process of manufacture, and are found in greatest number in the short fine wools used in the manufacture of cloth where the felting property is a very desirable thing.

There is some difference of opinion among those who have examined the structure of wool with the aid of the microscope as to the number and variation of these imbrications in different classes of wool.

We give the result of the observations of one party of observers to whose opinion we incline, which, though it may not be exact, will yet give a fair idea of the difference of structure in four well-known kinds of wool. It will be seen that the coarser the wool the fewer are the number of imbrications per inch; and as the finer wools are known by practical experience to possess the greater felting properties, it seems apparent from whence those properties proceed.

Kinds of Wool	Diameter of Fibre	Length of Fibre	Imbrications per inch linearly
	Inch	Inches	
Saxony	1/[illegible]	2	2,720
Long Merino	1/[illegible]	3½	2,400
South Down	1/[illegible]	2½	2,080
Leicester	1/[illegible]	10	1,860

For purposes of general classification all wool may be divided into three principal classes, viz., Leicester, or long wool; Southdown, or short wool, and half-bred or middle wool, which is a cross between the other two.

The most valuable of the long wools are those grown in the East Riding of Yorkshire, Nottingham, Lincoln, and Leicester. The superior value of these lies in what is known in the wool trade as lustre; that is, a peculiar silvery brightness of hair which it does not lose in process of manufacture.

This quality of lustre is only possessed by the four sorts named above, and a great quantity of the growth of Leicester and Nottingham must be excepted as not being purely lustrous. The wool of Lincolnshire and the East Riding of Yorkshire, however, is only excelled in lustre by alpaca and mohair.

It is a remarkable fact that, with the exception of the four counties named, lustre wool cannot be grown anywhere in the world. To cross any other breed of sheep with Leicester or Lincoln only imparts length of staple but not lustre. In fact, the Lincoln or Leicester sheep, when taken to any other part of England or the Colonies, rapidly deteriorates in this valuable quality.

The wool of a great many other counties, although not lustrous, is classed with the Leicester or long wools. In fact, this breed, as climate and other circumstances suit, is fast improving or superseding most of the other wool in England and other parts of the world. The desirable qualities in this class apart from lustre are, length and firmness of staple, which can be obtained by a judicious use of the Leicester ram, and soundness or strength, which may be secured by care and attention to the regularity of feeding on the part of the agriculturist.

Midway between the Leicester and half-bred classes comes the wool of Northumberland, Cumberland, and the good-bred wool of some parts of Scotland, as Caithness, Roxburgh, &c. This wool is extremely valuable, combining as it does to a great extent the length of staple of the Leicester with the fineness of hair and softness of the half-bred. This is known in the trade as North wool.

The next class in importance is the middle or half-bred class. The most valuable wools in this class are those grown in Shropshire, part of Staffordshire, which is now a distinct breed, but which originates in a cross between the Leicester and the Shropshire Down, and Norfolk, which is a cross between the Lincoln and the Southdown or Norfolk Down.

The desirable qualities in this wool are softness to the touch, fineness of hair, and as much length of staple as can be obtained consistently with fineness.

It is proper here to remark that the longer the staple and the heavier the fleece the coarser is the hair. Hence it follows that in those kinds of wool which depend for their value on fineness of hair, an increase of weight beyond a certain limit is not desirable.

The third class is the Southdown or short wool. The bulk of this wool is used in the manufacture of woollens. From its shortness of staple it requires carding, which, as far as regards the worsted trade, is an extra process, a process which the longer wools do not require to go through, and which entails additional cost. It depends for its value on its softness and fineness of hair, the latter more particularly. The best wool of this class grown in England is the pure Southdown. For a long time the most valuable and the most used of this class was the Spanish merino, large quantities of which were imported into and manufactured in this country. In 1807 the total quantity of wool imported into this country was 11,473,000 lb., of which 10,291,000 lb. was Spanish. After a time this wool was to a great extent supplanted by German or Saxony wool. In 1825, out of a total import of 43,817,000 lb., 8,206,000 lb. was Spanish, and 28,931,000 lb. German. These, however, have both been supplanted by colonial wool consequent upon the introduction of the merino sheep into the Colonies in the beginning of this century, which caused a revolution in the growth of fine wool. In 1843 the imports of colonial wool equalled those of Spain and Germany put together, and in 1877 out of a total import of 417,781,436 lb., 281,005,463 lb. were Australian and New Zealand, against 300,000 lb. Spanish and 6,700,000 lb. German. Some idea of the value of the fine colonial wool may be gained from the fact that some of it can be spun nearly twice as fine as the finest that can be grown in England.

There is another large class of wool which cannot be included under any of the foregoing heads, which may be called carpet wool, being used principally in the manufacture of carpets. This wool is badly bred, and is the growth of very cold countries where a good breed would not live, or is the produce of Eastern countries, where from great neglect the sheep is very near to the original *moufion*, from which our present breeds are said to have sprung. The chief characteristic is that each sheep grows two kinds of wool. A long coarse wiry kind of hair presents itself at the outer side of the fleece, covering a short, fine, and mossy fibre which grows next the skin. Under this head may be classed Russian, East Indian, Iceland, the bad-bred Scotch, and many others.

An element in all bad-bred wool is the presence of kemps, a small white hair,

which is very brittle and which will not take any dye. Wool containing kemps is of much less value than the good-bred wools, which are always free.

This may be strikingly illustrated by the present (1877) value of Scotch wool. The deep good-bred wool spoken of previously is worth, say, 15*d.* to 17*d.* per lb., whilst the price of bad-bred Scotch or Blackfaced is only, say, 9*d.* to 10*d.* per lb. These prices are for clean wool. The Scotch farmers, in order to protect their sheep which graze in exposed situations from the rigours of a Northern winter, have a practice of smearing part of their flocks with a composition of tar and butter. This is called laid wool, and is worth from 25 to 50 per cent. less than clean.

The skin of the sheep is formed of three layers. The outer cuticle is a thin delicate membrane of a scaly character, and devoid of feeling; the next is a mucous layer, in which feeling and also the colouring matter resides, which imparts its peculiar tints to the hair; the third, or true skin, is a dense, firm, and elastic membrane, from which the hair originates. A small cup extends from the third skin to the outer cuticle, in which the hair is implanted, growing, so to speak, in a kind of flower-pot, and receiving nourishment from surrounding vessels. The growth of the hair is from the root, the outer end preserving its character from its first appearance through the skin; the pointed and curly appearance of the wool of the lamb being still apparent when the sheep is clipped, as a hog in the second year of its age. It is this fact which enables the woolstapler to tell with perfect ease and certainty the difference between the hog or first clip and the wether, which is the wool from the sheep which have been clipped more than once.

The skin is studded with small glands, or what are called scientifically, sebaceous follicles, from which exudes a fine yellow soapy substance called yolk. This valuable substance is found in greatest abundance in the Southern and finer wools, and gives softness of touch to the hair. It seems to be a kind of soap provided by nature for the proper washing of the wool, as it is largely composed of potash and is found in its greatest quantity about the time of sheep-washing in the month of May.

Many agriculturists lose sight of this valuable substance, often washing their sheep in a large body of water or in a running stream, thereby losing the valuable scouring qualities of the yolk.

The best way of washing is in a large tub capable of holding five sheep, in which the water should not be changed but allowed to get as greasy as possible. After the first three or four lots the wool will be beautifully white and clean. After being thoroughly rubbed and scoured in the first tub they should be plunged into a second containing clean water or into a running stream, so that they may be properly rinsed out and cleansed from all impurities.

Within about a week of washing, or ten days at most, the sheep should be clipped, as, if they are allowed to run longer, the yolk again largely exudes from the skin into the wool.

The time of clipping is now much earlier in England than formerly. It commences about June 1, and is generally over throughout the country before the end of the month.

When the sheep is clipped, the wool is, or should be, carefully cleaned from dirt, straw, &c. The fleeces are then rolled up separately and fastened by a band, generally made by twisting part of the fleece and tying it round the rest. This is called winding, and after this process it is ready for the market. It is then sold to the woolstapler or spinner. For its treatment in their hands, see article Worsted.

The foregoing remarks apply to fleece wool, or wool that is clipped from the living animal.

There is, however, a large quantity of wool called skin wool, which is obtained from the skin after the death of the sheep. The skins with the wool on are sold by the butcher to the fellmonger, who washes them, and by sprinkling them with lime or other preparations loosens the wool from the skin, so that it can be pulled off by hand.

If pulled late in the season when the wool is equal in length to the fleece wool, it is used for the same purposes, but from having lost its lustre and liveliness of appearance, and also because of the presence of lime, and generally a larger amount of dirt, it is inferior in value, generally rating about 2*d.* to 3*d.* per lb. less than the fleece wool of the same length and description. The short skin wool, *i.e.* what is pulled soon after clipping time, is used in the carpet, woollen, and hosiery trades.

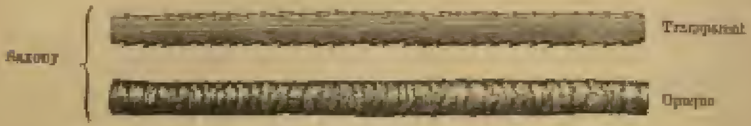
Another kind which does not come under the head of fleece is lambs' wool. It is found beneficial in some of the southern counties of England, and in some of the colonies, to clip the lambs at the time of clipping the full-grown sheep. This wool is used in the hosiery and woollen trades, the finest colonial lambswool being used in the manufacture of felt hats.

Alpaca and mohair now occupy an important place in our manufactures. From

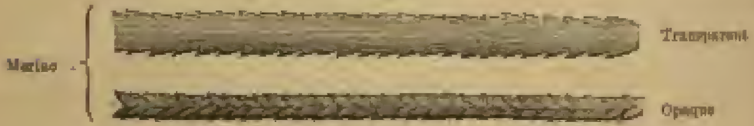
their remarkably bright and silvery qualities they are of great value, the present prices (October 1877) being alpaca 1s. 11d. per lb., and mohair 2s. 11d. per lb. They are used in the manufacture of what are known as alpacas, lustres, and Orleans.

To the naked eye they have a somewhat similar appearance, but when examined under the microscope the structure of the hair is found to be different. Both are imbricated in the same manner as wool, though in a much less degree, but alpaca has also the medullary or marrow in the centre similarly to ordinary hair, while mohair, like wool, is without it.

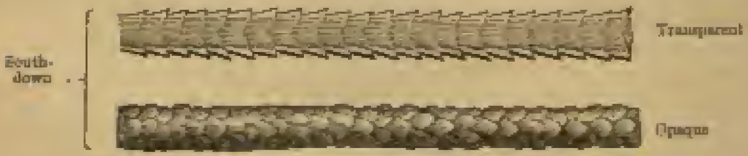
2575



2576



2577



2578

2579

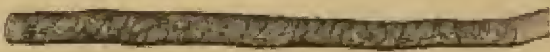
From the following statistics will be seen the relative production of wool in different parts of the United Kingdom; and the growing importance of the wool trade to this country may be gathered from the enormous increase during this century in the imports of foreign and colonial wool, and from the total amount of home and foreign wool we now yearly manufacture at home.

Figs. 2576 to 2579 inclusive are not magnified to any fixed scale, but are simply pictures given to show the characteristic features of each kind of wool. When viewed

2580

Human Hair .  Longitudinal Section / External Surface

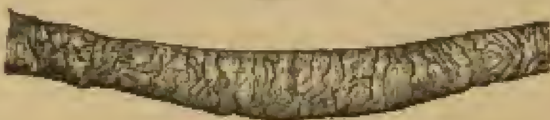
2581

Hair of Kid .  Fine

2582

Hair of Calf  Coarse

2583

Ordinary Wool . 

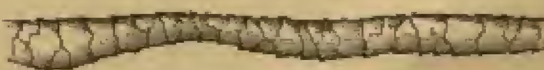
2584

Hair of Cow  Fine

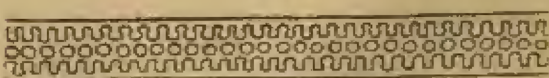
2585

Mohair . . 

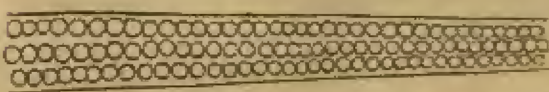
2586

Wool . . . 

2587

Hair of Mouse . 

2588

Hair of Rabbit . . . 

through the microscope as transparent objects, the markings of the outer edge of the fibre are seen. Viewed as opaque objects, the markings of the entire surface are visible.

Fig. 2580 is from Dr. CARPENTER'S *Microscope*, p. 719. *Figs.* 2581 to 2584 are magnified 310 diameters by TOLLE'S microscope, photographed for the Wool Manufacturers' Association of the United States. *Figs.* 2585 and 2586 are magnified 490 diameters, and show the difference between mohair and ordinary wool both of the same fineness. *Figs.* 2587 and 2588 are magnified 200 diameters.—J. W. T.

Wool, Chemical Purification of.—The removal from wool of the so-called 'burrs,' *i.e.* fragments of straw, thistles, and other vegetable matter, which, getting entangled in the fleece of sheep, accompany the wool through all stages of its manufacture, is a matter requiring attention. As the burrs do not take the same dyes as the wool, the goods must either be submitted to a separate process of burl dyeing, or the spots must be touched with special solutions made for the purpose—'burling inks'—or, lastly, the burrs must be plucked out by hand with pincers. Processes have therefore been patented, by FENTON and CROWE in England (1853), and by TYART and LECOUP in France (1854), for destroying these 'burrs' with acids. The process consists in steeping the wool, either raw or woven, in sulphuric acid at 3° or 4° B., draining it in a centrifugal machine, and drying it in a stove at 100°. The authors have examined all circumstances of this process: they find that the addition of alum and salts of tin to the destroying acid has no good effect, and greatly interferes with the subsequent dyeing operations; that the draining in the centrifugal machine cannot safely be dispensed with; and that the following limits of heat, proportion of acid, and time of action, cannot safely be exceeded. If the stove is at 80° C. and the goods are to be heated two hours, the acid may run from 1½ to 4½ litres for 100 of water; if it is to be heated only half an hour, the acid may range from 3 to 7 litres. If the stove is at 110°, the acid is 1 to 3 litres per cent. for two hours, and 1½ to 4½ for half an hour. If the heat is 150°, the acid should be ½ to 1 litre per cent. for two hours, and 1 to 1½ litre for half an hour. Very prolonged washing with hot water, alkaline solutions, and cold water, is required to remove all superfluous acid after the burrs are destroyed. Without great care the nature of the wool is affected, and its affinity for dyes enfeebled.—MM. DUCLAUX, LECHARTIER, and RAULIN, *Chemical News*, July 10, 1874.

Utilising Waste Water from Scouring.—DAUDENART and VERBERT have a patent process for utilising the waste water after scouring wool. The water is mixed with a solution of caustic baryta as long as a precipitate is formed. When this has settled the clear liquid is drawn off and evaporated to dryness, and the residue ignited, yielding a mixture of potash (or soda), with a little chloride of calcium. The fatty acids are separated from the precipitate by means of hydrochloric acid, washed, and pressed. The solution of chloride of barium is mixed with hydrate of magnesia until all the baryta is precipitated, and then the carbonate of baryta is reconverted into caustic baryta by ignition with charcoal.—REIMANN'S *Färber Zeitung*, No. 44, 1873.

Wool Imports, 1875 and 1876.

	1875		1876	
Alpaca, Llama, and Vicuna.	Lb.	Value	Lb.	Value
From Peru . . .	3,610,053	£472,761	3,115,514	£346,899
,, New Granada .	154,741	22,794	—	—
,, Chili . . .	397,406	56,307	339,809	43,329
,, other Countries .	108	8	32,113	3,027
Total . .	4,162,308	£551,870	3,487,436	£393,255
Sheep or Lambs.				
From Russia, North Ports . .	3,648,119	£159,463	2,650,257	£125,447
,, Russia, South Ports	11,436,525	557,262	10,207,924	468,000
,, Denmark . .	2,883,929	161,115	2,746,462	151,542
,, Germany . .	7,320,760	500,131	8,371,549	577,450
,, Holland . .	1,359,425	90,211	3,168,297	201,668
,, Belgium . .	2,655,829	177,826	2,891,909	175,106
,, France . .	1,548,206	87,027	1,675,527	98,157
,, Portugal . .	1,460,654	75,731	1,569,144	76,178
,, Spain . . .	612,431	30,967	—	—
,, Italy . . .	177,327	9,260	87,775	5,221
,, Austrian Territories . .	699,189	34,267	117,342	5,574

	1875		1876	
Sheep or Lambs—(cont.).	Lb.	Value	Lb.	Value
From Turkey . .	5,504,094	£271,134	6,059,140	£297,789
" Wallachia and Moldavia .	310,438	15,193	—	—
" Egypt . .	2,247,769	100,362	3,569,808	142,340
" Morocco . .	2,561,096	124,752	2,100,278	85,094
" China . . .	492,223	22,806	502,420	20,568
" United States of America . .	708,195	34,921	548,410	21,206
" Peru . . .	2,915,723	140,591	3,132,951	156,235
" Chili . . .	350,021	23,092	227,313	15,227
" Brazil . .	357,435	16,647	172,330	6,147
" Uruguay . .	1,110,529	45,540	1,005,450	47,168
" Argentine Republic . . .	2,744,540	97,035	2,553,258	90,423
" Gibraltar . .	850,538	40,057	135,480	6,541
" Malta . . .	—	—	112,646	6,128
" British Possessions in South Africa	44,112,213	3,007,046	42,168,317	2,755,401
" British India, Bombay, and Scinde	22,080,126	952,490	24,418,415	985,001
" Australia . .	238,631,716	16,041,371	263,800,157	16,645,769
" Falkland Islands	672,506	35,283	854,164	42,212
" other Countries .	854,095	41,790	707,116	30,554
Total . .	360,903,276	£22,695,543	385,568,323	£23,244,564
Other kinds and Wool Flocks.				
From France . .	298,825	£6,878	181,978	£9,278
" other Countries .	232,755	7,596	147,550	3,105
Total . .	531,580	£14,474	329,528	£12,353

Woollen Yarn.

	1875		1876	
For Fancy Purposes.	Lb.	Value	Lb.	Value
From Germany . .	488,925	£105,768	672,496	£133,996
" Belgium . .	92,550	15,894	7,740	2,088
" France . .	140,835	24,777	160,350	26,102
" other Countries .	4,904	610	1,292	201
Total . .	727,214	£146,049	841,878	£162,387
For Weaving.				
From Germany . .	5,119,632	£557,080	4,495,741	£512,473
" Holland . .	271,720	29,934	219,413	23,174
" Belgium . .	6,186,641	728,497	7,952,237	960,199
" France . .	122,935	12,386	212,511	42,650
Total . .	11,700,928	£1,327,897	12,900,902	£1,538,496
Unenumerated.				
From France . .	—	£14,106	—	£27,681
" other Countries .	—	4,075	—	8,684
Total . .	—	£18,181	—	£36,365

Wool imported in 1877.

	Lb.	Value
From Countries in Europe	36,930,663	£1,949,033
„ British Possessions in South Africa	41,522,420	2,741,410
Sheep and Lambs.		
From British India	21,568,366	854,088
„ Australia	281,005,452	17,593,581
„ other Countries	24,913,360	1,066,482
Total	405,949,161	£24,204,595

	Lb.	Value
Alpaca, Vicuna, and Llama	3,561,806	£362,622
Goat's Wool or Hair	8,270,469	932,147
Woollen rags to be used as Wool	75,010,880	760,343
Woollen Yarn	12,949,117	1,540,187

WORSTED AND WORSTED STUFFS. In the earlier editions of this work the worsted manufacture was included under the head 'Woollen Manufacture.' This arrangement was then necessary in consequence of the two industries existing side by side and many of the operations being somewhat similar. The worsted trade has now become such a large and important one, and is differentiated in so many particulars from the woollen trade, that it becomes necessary to treat it separately. This article, however, must be read in conjunction with the articles WEAVING, p. 1110, and WOOLLEN MANUFACTURE, p. 1157, in the third volume of the seventh edition.

Worsted is the cloth made entirely of long wool. Authorities differ as to the origin of this name. The common opinion is that it is derived from the town of Worstead, in Norfolk, where it was first made. But the probability is that the town was called after the trade, and not the trade after the town, as in some old documents the town is called Wolstede, or place of wool.

Worsted goods, of which both the warp and weft consist of long wool, have been manufactured in different places in this country, but early in the present century the trade seems to have fixed itself in Bradford and the surrounding district.

Cotton warps were introduced about the year 1834, and their use rapidly increased; and at one time it might be said that the entire of the production of the worsted district consisted of goods of which cotton formed the warp. These goods are designated generally worsted stuffs, with an infinite variety of particular names. It is from this point that worsted must be considered as commencing its existence as a separate trade.

The qualities of felting and milling in wool, which are so much sought after for woollen goods, are not required for worsted, and would in many cases be a positive disadvantage. As worsted stuffs are chiefly light and thin materials, used for ladies' and children's dresses, or for the linings of coats, the wool used in their manufacture must be long and straight, so that when woven with the cotton warp the surface may be flat, smooth, and firm.

A concise statement of the treatment of long wool for use in the worsted trade is from a paper read before the Wisbeach Chamber of Agriculture.[1] The figures are corrected up to the present date (1878):—

'Wool is generally bought from the farmer by the woolstapler, who first of all divides the hoggs from the wethers, takes out all cots, unwashed skins, and black fleeces, generally selling each lot to separate branches of the trade. This we call classing the wool. The next process is sorting, which is sometimes done by the stapler, and sometimes by the manufacturer. Each fleece contains about eight sorts, viz., three short and five long. The method of proceeding is as follows:—The sorter, who works by the piece, and has about 5s. per pack, or one farthing per pound for his work, first takes and untwists the wool band, and rolls the fleece open on the floor. When he has got it properly open he divides it down the back, from the tail to the head, in two equal parts. He then gathers each side carefully up, making it into a kind of roll, and lays it on a pile. When he has opened what he considers sufficient he begins to sort. He takes a side up and puts it on his board, which is a kind of table about 9 feet long, having three small compartments or bins underneath for the short sorts. After having picked off the straws, which ought to have been picked out by the winder, and cut the dung off the tail, which ought to have been cut off by the shepherd, he proceeds by pulling off the short wool, which those who have clipped sheep will know grows from the throat down underneath the animal. These he divides into three sorts, which are known as shorts or brokes, and are called respectively downrights, seconds, and abb, the best being that grown nearest the head,

[1] Mr. J. W. TURNER 'On Wool,' June 12, 1871.

and the worst nearest the tail. Sometimes, in very fine fleeces, a fourth short sort is made, which is called head, and is better than the others. These short wools are all used for the clothing trade, that is to say, they are made into cloth, and not worsted stuff. Having got off the short, he begins to divide the rest of the fleece into its proper long sorts. These sorts are called by different names in different parts of the country. In Bradford we call the sort nearest the tail breech, the next brown, neat, blue, and fine. In order that these divisions may be more thoroughly understood, I will call them by the names which the spinners give to the yarns into which they are spun, and you will see the reason for this when I come to speak of spinning. The lowest sort, as I said before, is that over the tail, which I will call 24's, the next 30's or brown, next 36's or neat, next 40's or blue, and 44's or fine. In Lincoln fleeces there is very little 40's and no 44's. From the following particulars you will be able to judge of the respective values of different kinds of fleeces to the woolstapler, in proportion to their fineness, and the amount of the dearest sort they will produce.

Name and Quality of Sort	Five Long Sorts					Three Short Sorts			
	Fine	Blue	Neat	Brown	Breech	Downrights	Seconds	Abb	Shittings[2]
	44's	40's	36's	30's	24's	[3]	[3]	[3]	
	d.	d.	d.	d.	d.	d.	d.	d.	d.
Present (1878) value per lb. in wether sorts	19	18	16½	15	13	14	11	8	2
Do. in hogg sorts[1] . . .	20	19	17½	16	14	14	11	8	2
Name of County as under	Percentage of above Sorts as under								
Lincoln hoggs	0	24	50	15	7	1	1	1	1
Yorkshire do.	5	30	38	15	7	2	1	1	1
Leicester do.	8	34	30	15	5	2	3	2	1
Northumberland do . . .	9	25	36	15	7	3	3	1	1
Nottingham do.	7	24	35	20	7	2	3	1	1
Norfolk do.	30	25	10	10	7	3	2½	1	1½
Lincoln wether	0	12	50	25	7	2	2	1	1
Yorkshire do.	0	36	40	12	6	2	2	1	1
Warwick do.	4	31	40	12	5	3	2	2	1
Somerset do.	4	35	29	18	6	2	3	2	1
Kent do.	56	20	19	7	4	[4]	[4]	[4]	[4]

When the wool is sorted the sort required for use is taken to the wash-house, and placed in a large iron bowl full of boiling water and soap. Here it is stirred about with forks, until every particle of grease and dirt is boiled out of it. It is then placed between rollers, heavily weighted, so as to squeeze all the water out of it, and is caught at the other side by a revolving fan, which partially dries it and scatters it over the room, and it is afterwards thoroughly dried by means of hot air. I shall not take up your time by attempting fully to describe the machinery of the succeeding processes, but will show you samples of the result of each process on the wool. The first is preparing, which is getting the locks of wool to lay even and regular ready for the worsted comb. The combing machine is perhaps the most interesting machine in the worsted manufacture. It consists in the first place of what is called the comb head, where the machine is fed with wool, and is composed of a number of straight pieces of steel filled with pins, called fallers; these are continually moving forward by means of a worm at each end, and one by one fall down at one end and rise up at the other end of the worms, and the wool is by this means drawn towards the nip, travelling about 14 inches. The nip, which is a piece of mechanism very much resembling the human hand, draws the wool in handfuls, so to speak, from the fallers, and lays it on the comb; by this means one end of the wool is combed. The comb consists of a large

[1] These prices are for lustre sorts.
[2] Dung, &c., chiefly.
[3] Not spun in the worsted trade.
[4] Less than half per cent. of each short sort.

copper circle, studded with pins which point upwards, the circle revolving horizontally (see *fig.* 2596). The wool, as it is laid on the pins of the circle, is knocked to the bottom of the pins by a brush, and from the circle a pair of rollers draws the long hairs of the staple out into one long continuous sliver called top. The short wool is left in the comb a few seconds longer, and is scraped out by means of a kind of self-acting knives; this is called noil.

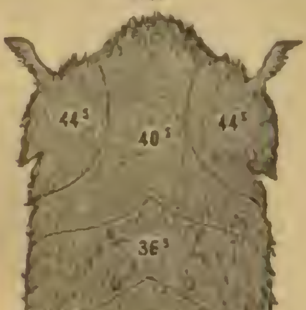
'I average bright wool, say, of 36's quality after the process of washing and combing will yield—Top, 11 lb. 13 ozs.; noil, 1 lb. 3 ozs.; sinkage, 3 lb.; total, 16 lb.

'From this point the top goes through two distinct processes—drawing and roving—passing through one or more machines in each. These may be described as a process of attenuation; the top is drawn out a little and given a slight twist by each machine, so that, in poetic language, it becomes, "Smaller by degrees, and beautifully less," until it gets into yarn.

'Spinning is a most delicate and scientific operation, and requires the greatest calculation and care. An explanation of this will show you that sorting is not a mere fanciful proceeding. We will suppose that 40's is the sort selected, which, as I told you, is practically the best sort off a Lincoln fleece. After having gone through the other processes the spinner has a well-defined task to perform, viz., to spin a certain weight to a certain length. The term 40's means that there are forty hanks of yarn to the pound, each hank measuring 560 yards. So that in a pound of 40's yarn there are 22,400 yards, or nearly 13 miles (12 miles 1,280 yards). It would be impossible to get this length from 1 lb. of wool off the tail of the sheep, as there is not hair enough to do it, and that is the reason why wool is sorted. Perhaps you will see it more clearly by having it calculated out. Breech wool will spin to 24's, that is, twenty-four hanks to the pound, which produces 13,440 yards, or nearly 8 miles (7 miles 1,120 yards).

'From this you have the startling fact that 1 lb. of wool off the shoulder of a good sheep will make 5 miles more yarn than 1 lb. off the breech of the same animal.'

2589



Annexed is a sketch of a Leicester wether fleece, the dotted lines showing the probable point of division between the different sorts.

The full list of processes through which wool goes before it becomes yarn are as follows: 1, washing; 2, drying; 3, preparing; 4, combing; 5, drawing; 6, roving; 7, spinning. In drawing and roving there are sometimes modified intermediate processes to suit special requirements.

As, however, several of these processes are noticed in the article on woollen manufacture previously referred to, we shall only notice in the present article machines which, being distinctively worsted and modern, have received no notice there.

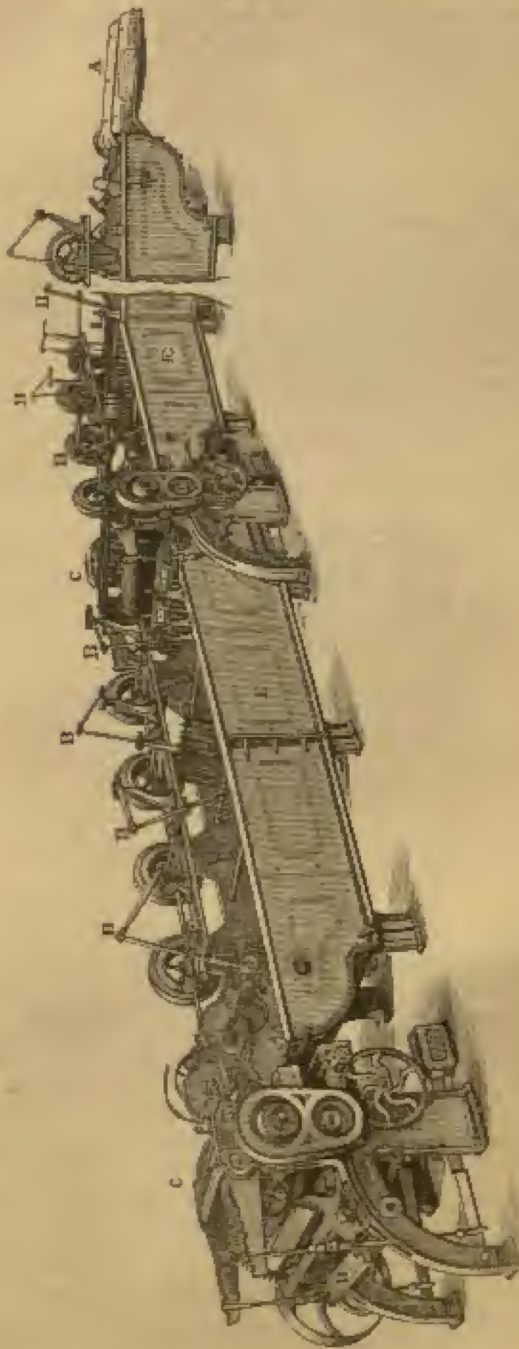
1. *Washing.*—In the newest machinery the wool is not now stirred about by hand, but by automatic forks, as shown in *fig.* 2590. The wool is placed upon the leather apron, A, from which it is passed into the sud tank, E, and passed forward by the forks, B, passing in its course under the weighted squeezing rollers, C, and being finally thrown out, partially dry, by the revolving fan, D.

2. *Drying.*—Most of the old systems have now given way to the hot-air drying machine, which does the work much quicker and more effectually.

The one shown (*fig.* 2591) is the manufacture of Messrs. J. and W. McNaught, of Rochdale. The surface of the machine is an open wire trellis-work, A, underneath which are a number of steam cylinders fed from the pipe, B. The heat given off by the cylinders is driven through the wire work by means of revolving fans, driven by the drums, C. At D the machine is shown covered with wool.

3. *Preparing.*—Instead of the carding process used in the woollen trade as a preliminary to combing, the wool is, after drying, submitted to a process called preparing, by being passed through machines called gill boxes. The machine (*fig.* 2592) is fed at A, the wool passing over a number of iron bars studded with steel pins, called fallers. These move forwards by means of a spiral screw at each end, and are so constructed that, when the journey forward is completed, they fall on to a lower slide, and are then moved back by another screw, on reaching the end of which they are shot up into position as at first. The effect of this is to pass the wool forward on to a sheet revolving upon the rollers, B B.

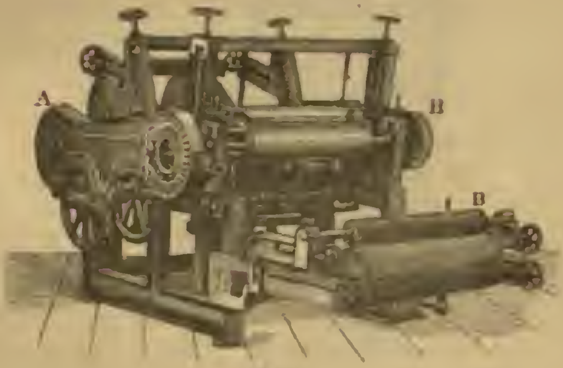
2590



This process lays the staples flat and resolves the wool into a continuous mass, which is taken off the sheet from time to time and put into the second machine (*fig.* 2593) at A. The process here is the same as in the previous one, except that the wool is pulled out a little more and delivered into a can at B, instead of on to a sheet as in the machine, *fig.* 2592.

2591

2592



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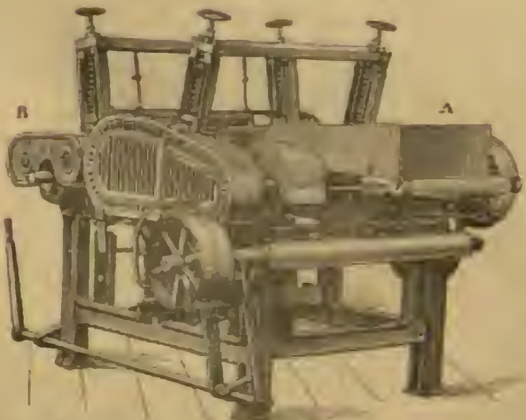
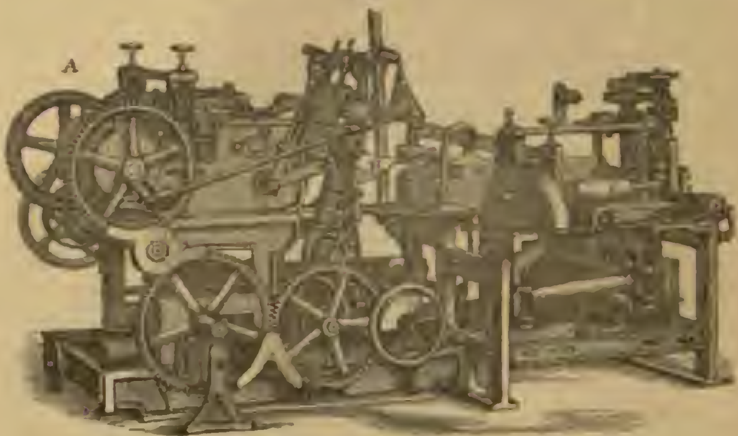


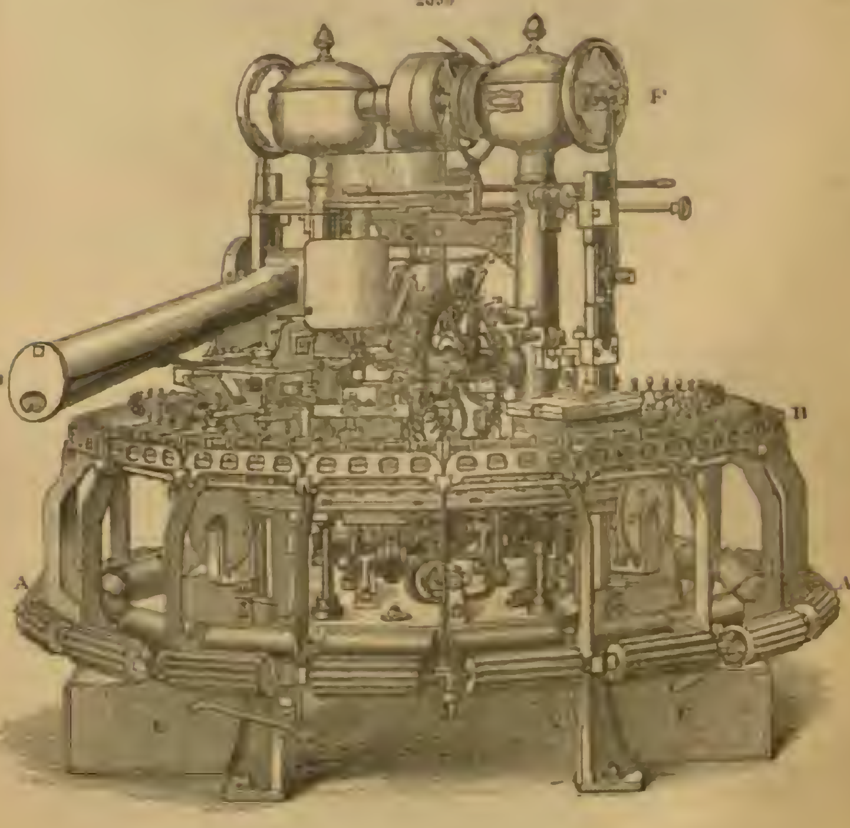
4. *Combing.*—The principle of the square combing machine has been described at pp. 1159–1160, vol. iii. of this work.

The machine here shown (*fig.* 2594) is manufactured by Messrs. SHACKLETON, HOYLE, and Co., of Keighley, and contains all the latest improvements. It is fed

2594



2595



with prepared wool at A, which passes over a series of fallers, at the end of which it is seized by a nip, B, which draws out a handful, so to speak, and places it upon the comb circle, C, into the teeth of which it is struck down by the brush, D. As the comb circle moves slowly to the right, the long hairs of wool are drawn out of the comb teeth by an arrangement of leather bands revolving over rollers and working face to face. These leathers deliver it to the rollers, E, from which it passes into cans. This portion is called top, and is the only part used in the worsted trade.

The short hairs are lifted out of the comb teeth by stationary knives, placed a little past the leathers, passing into a box below. This short wool is called noil, and is used for woollen and other purposes.

Several parts of this machine are separately patent. Among others the nip, B, or at all events its circular shape, is the patent of Messrs. W. Berfield and Son.

The most modern combing machine in general use, for combing wools of medium length which it is thought desirable to card, is the round comb, manufactured by Messrs. Taylor, Wordsworth, and Co., of Leeds (*fig.* 2595). Four balls of the carding, one above another, are placed upon each one of the loose rollers, A, an end of the carding passing through each of the holes, B. As the entire outer framework of the machine moves round, each end of the wool is successively dabbed down by the brush, C, its subsequent treatment being similar to that in the square comb. The top is delivered by the funnel, D, and the noil into the boxes, E.

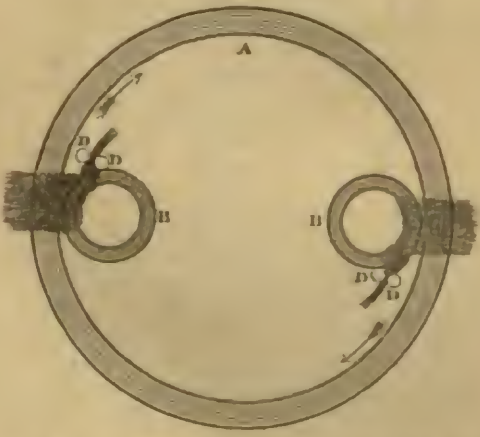
This comb is double in its action, having two smaller comb circles inside the larger one, the point of contact between these being just under the brush where the real combing work is done. It is hardly possible to describe this machine. It must be seen to be understood.

The wheel, G (*fig.* 2595), which prevents the wool from rising while being drawn from the larger comb circles by the smaller ones, is sometimes replaced by a stream of air conducted to the place by a tube.

In a new patent the working of the brushes by the crank motion, F F, is superseded by a belt working from the wheels at F F, and revolving a cam to which the brushes are attached. It is said to be a great improvement, but is not yet in general use.

The principle of the round comb is shown in *fig.* 2596. A is the large comb circle B B the small comb circles. The wool is padded on to both combs at C. Both revolving

2596



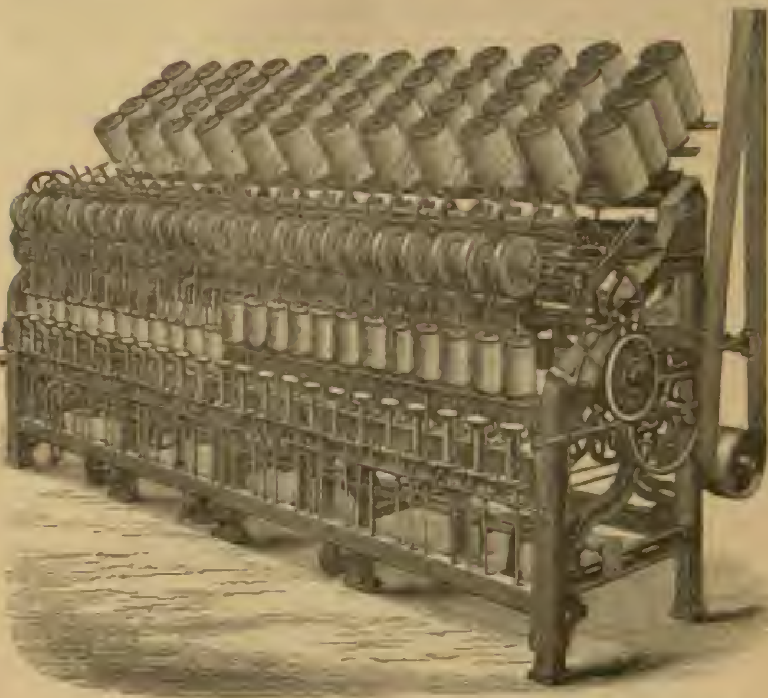
in the same direction, the smaller comb draws the wool out of the larger, thus combing one end of the wool. The combed end is then seized by the rollers, D D D D, which draw it out of the smaller comb, thus combing the other end. It is then, by means of leathers, conveyed away in a continuous sliver.

5 and 6. *Drawing and Roving.*—Instead of the breaking frame (*fig.* 2127, vol. iii.), machines which in their earlier stages are a refinement of the preparing box previously noticed are used, called drawing boxes (*fig.* 2593) and roving frames (*fig.* 2597). In each of these processes the wool becomes slightly more attenuated, and receives a slight twist, the final twist being given it in spinning.

7. *Spinning.*—The ordinary flyer spinning frame, the principle of which is described in previous articles, is a modification of the roving frame, *fig.* 2597, the yarn being

received by bobbins having a flange at the bottom only. See SPINNING, and WOOLLEN MANUFACTURE.

2597



A modern machine in general use for spinning the finer yarns is the cap frame, a steel cap taking the place of the flyer spindle. This cap is placed loosely over the bobbin, allowing the yarn to go in at the bottom, so that as the bobbin fills with yarn the cap rises, the wrapping of the yarn on to the bobbin being thus even all the way up, and finishing at the top.

Weaving.—Figs. 2598 and 2599 may conveniently be taken as the basis of illustration for some general remarks upon modern looms used for weaving plain and fancy fabrics for the worsted trade. It will be seen that great strides have been made in the excellency of this class of machinery since the article WEAVING in vol. iii. was written.

Plain or one-shuttle looms are made in all widths, from 24 to 180 in. reed space, and are built in two methods, viz. fast reed and loose reed.

Fast-reed looms are generally used for heavy goods, where stability is required, and also in nearly all plain looms above 50 in. reed. The motion consists in having the reed a fixture, so as to obtain firmness in driving up the weft. This motion is so arranged that, should the shuttle be prevented from reaching its proper place before the beating up of the weft, a stoppage of the loom ensues. This is accomplished by a lever which projects into the recess for the shuttle; and should the shuttle be absent, the lever comes in contact with a casting, capable of sliding in a socket and communicating with the driving apparatus, *a*, and break motion, disconnecting the one and bringing into operation the other.

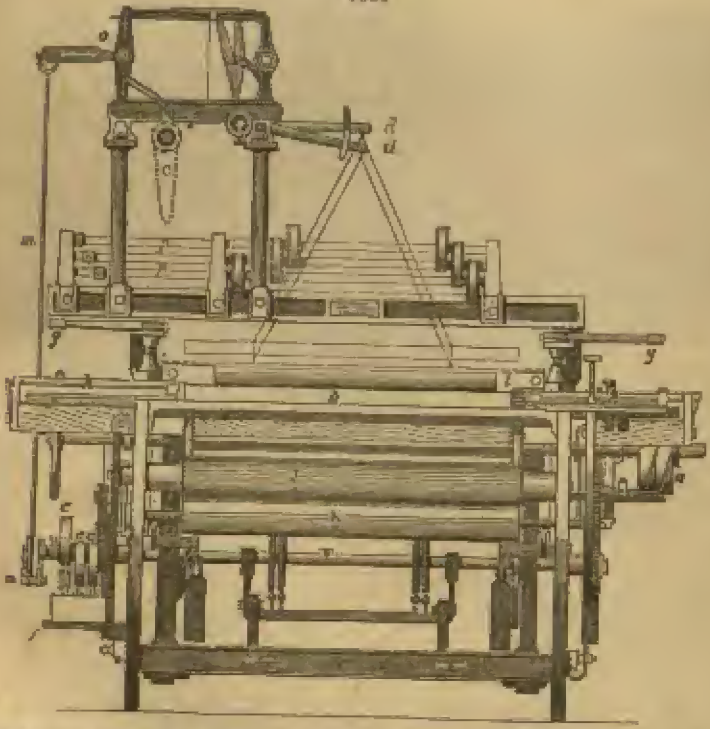
Loose-reed looms are generally used for light fabrics, and where great speed is required combined with ease in action. The reed is swung by its top in a recess of the hand tree, *b*, the lower end free, and being kept at its proper place by a lever, which, when driving up the weft, is locked so as to obtain sufficient strength for that purpose. This motion is so arranged that, should the shuttle stop during its passage from one side of the cloth to the other when the slay, or reed, is moving to drive up the weft, the shuttle comes into contact with the warp and reed and displaces the lever, whereby the shuttle is prevented from doing any damage to the warp. At the same

time that the lever is depressed it comes into communication with the driving motion and break, and stops the loom instantly.

The treading motion is placed at the opposite end to the driving motion, and consists of a series of treadles worked by cams, *c c c*, communicating to the healds through an equal number of horizontal shafts, *p p*, placed above the loom, having attached to them levers for raising or depressing the healds, the number of treadles so employed varying from 2 to 12.

The motion for picking the shuttle is arranged in two ways, the one most in use being termed the overpick. It consists of a cam, *c*, being placed on the second motion shaft, *v*, which oscillates an upright shaft, to the top of which is fixed a

2598

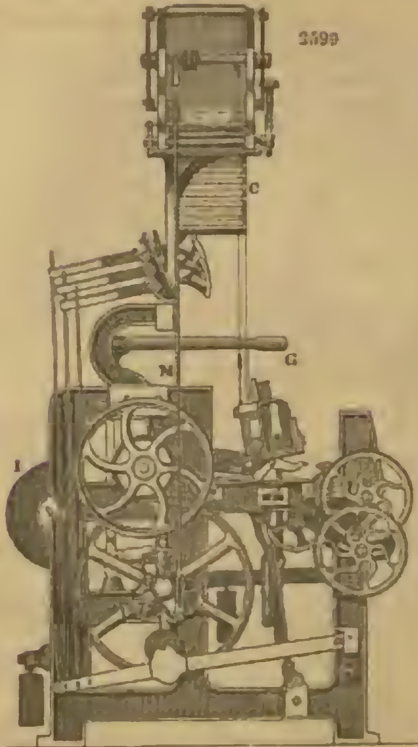


horizontal arm of wood, *g g*. To the free end is attached a leather strap, which at the other end is fixed to a picker sliding on a spindle, *h*, for driving the shuttle.

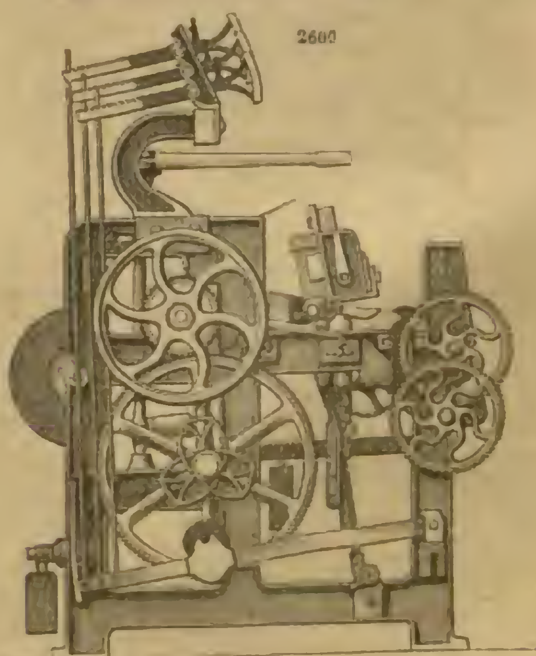
In the letting-off motion the unwinding of the warp from the beam, *i*, is regulated by friction, a piece of rope being wound round the end of the beam, communicating with a lever and weight of the third order. Friction is also employed in the setting-up motion. An iron cylinder, *t*, with a rough surface, revolves by means of wheels worked by a pawl and catch-wheel, the intermediate wheels being made to change so as to obtain any degree of fineness required. The woven piece passes partially round the cylinder, and is conducted on to a wooden roller, *x*, held in contact with the iron cylinder by means of levers and weights. The weft fork, *l*, is a piece of mechanism for detecting the absence of the weft. By the action of the slay the weft threads are carried in succession to be embedded with the warp, and a delicately-poised lever in communication with the driving motion, having a notch at one end, is suspended ready to feel for the presence or absence of each individual shoot of weft. Should the weft be absent, the notch in the lever is caught by the receding movement of a lever worked from the second-motion shaft by a tappet, which instantly stops the loom, and at the same time prevents the piece being drawn forward by lifting the pawl operating on the catch-wheel.

Fig. 2600 is the perfectly plain one-shuttle loom for weaving Orleans, cordurovs, merinos, satteens, serges, &c. It has been brought to great perfection and can be

2599



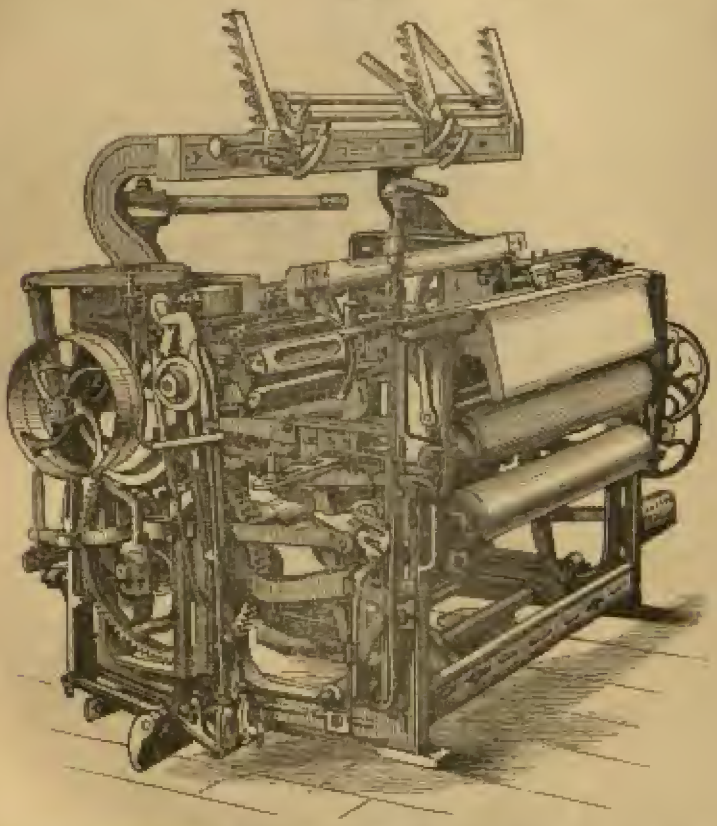
2600



worked at great speed. The foregoing references to *figs.* 2598 and 2599 apply also to this loom.

Fig. 2601.—Looms for the manufacture of check goods are very much improved and simplified, and have attained such perfection that ordinary and simple patterns of six colours can be produced at nearly the same speed as plain goods of one shuttle. The six shuttles are arranged in a circular box of six compartments (A), and when

2601



one shuttle has put in the requisite number of picks, the circular box is made to revolve to the next compartment in either direction, as may be required.

Fig. 2602.—Though the ordinary six-shuttle box loom described above has attained such perfection, there are some goods, such as clan tartans, which cannot be made by it. The most perfect loom used for these goods is one patented and made by George Hattersley and Sons, Keighley.

The mechanism of this machine is so perfect that when No. 1 shuttle (see diagram 2603 and *figs.* 2604 and A 2602) has completed its allotted number of picks, the circular box is made to revolve so as to bring up for the next pick either No. 2, 3, 4, 5, or 6, and though the distance from No. 1 to No. 4 is very great, the shuttle box is made to revolve and stop at its proper position with the greatest accuracy, as indicated by the pattern card motion (see *figs.* 2598 and 2599 C), which is always arranged before commencing to the required pattern of cloth, and with the loom making 140 picks per minute. This machine is called the skipping box-loom.

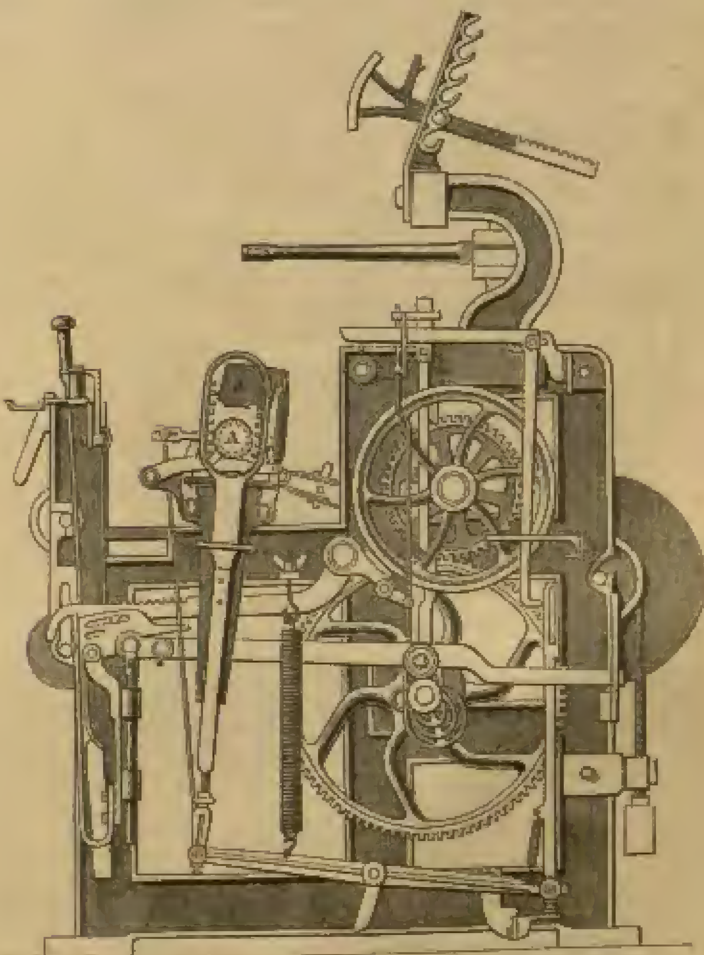
Fig. 2605.—Hattersley's patent heald machine as used on one-shuttle loom. By this machine an almost endless variety of goods is made in small figures, large twills, stripes, and cross-overs, which are quite out of the range of the ordinary tappet weaving. It is a separate machine fixed on supports above the loom, and can be

worked with or without the jack rods, *p p* (see *fig.* 2598), and without displacing them. An upright rod, connected to the second-motion shaft by a swape, *s*, works a T lever, *n*, to two ends of which a knife is attached working in guides. These knives are for operating on two sets of catches attached to each end of a lever having the fulcrum in the centre, this fulcrum being hinged to another bell-crank lever attached to the healds. Over 10,000 of these looms have been made within the last three years.

A great many special looms, being mostly modifications and combinations of those before noticed, are also made for weaving silk reps, lastings, damasks, table covers, and various other goods requiring one surface of the piece to be different from the other.

Among these the most noteworthy is the pick and pick loom, having a two-shuttle box at each end of the slay board, and which can be actuated at any or every single

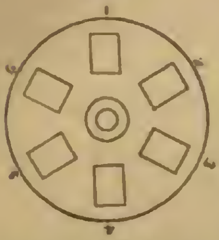
2602



pick of weft. This loom, fitted with HATTERSLEY'S patent heald machine, can be worked at a speed of 120 picks per minute, the speed of the old loom for the same purpose being about 45 picks per minute. It is largely used for coatings, ladies' mantles, and other all-wool goods.

There are many minor inventions of great service and convenience to the trade. Among these is a machine for warp dressing, dispensing to a large extent with the old hand labour.

2603

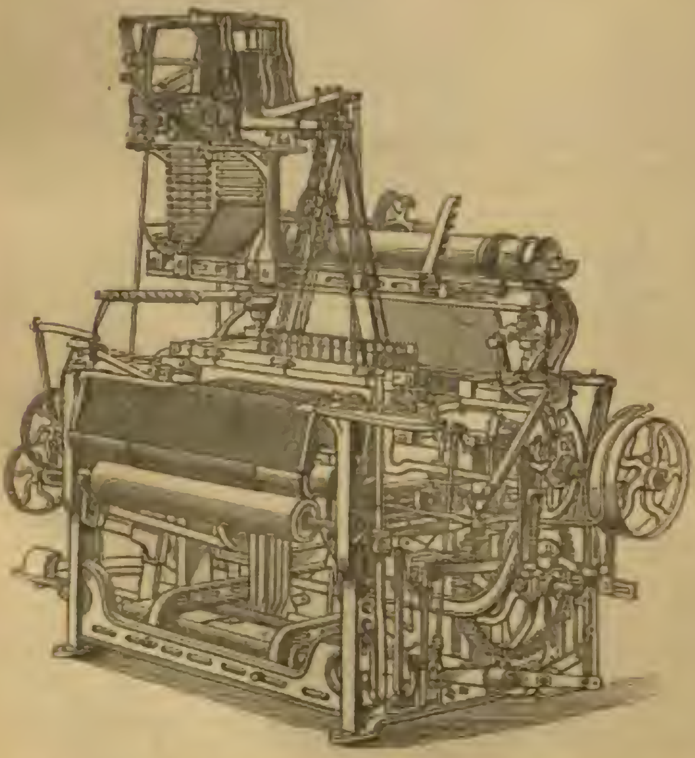


During the last two years the worsted trade has suffered, along with others, from the general commercial depression. It has also felt severely the effect of the dearness of labour and the shortening of the hours of work. It has had to struggle against foreign competition and prohibitive tariffs. But with all this it must nevertheless be said that the last twenty years have seen in it a continual growth, and, with the same energy and invention and enterprise which have characterised it in the past, there is reason to hope for a continued prosperity and a still greater importance for it among our national industries.

Carpets and Rugs.—In vol. i. p. 782 will be found a description of the carpet loom and some general information respecting the manufacture of carpets.

Carpets were at one time always hand made, but, although rugs are sometimes

2604



still made by hand, carpets are now rarely so constructed in this country, although a few are still made by hand at Cleckheaton. It is stated that in Persia the hand-made carpet is common still.

The introduction of the JACQUARD loom (vol. iii. p. 1) completely changed the processes by which carpets were made.

The Kidderminster carpets, so called, as are those also made at Axminster, from the town in which they were manufactured, were the first in this country made by a mechanical contrivance. The Kidderminster carpet has a worsted warp and a woollen

weft.' It is a double or two-ply carpet—that is, the double thicknesses are interlocked at intervals. It is, in its best form, produced from yarns of only two or three colours. The three-ply or three-fold carpet made at Kilmarnock is composed of three webs, which by interchaining their threads produce a pattern on both sides.

Brussels carpeting consists generally of six thicknesses of worsted, and threads of hemp or jute, which knit the worsted threads together and form the 'backing,' the under part of the carpet.

The yarn which forms each thickness of the carpet is derived from separate frames or reels. The frames of worsted are placed more or less horizontally behind the loom, and in order to supply the worsted for each thickness of the carpet, there is a large frame, which is crossed by strong wires one beyond the other, like the rounds of a ladder; each wire supplies a number of large reels, and each reel supplies one thread of worsted to the loom. Of these reels there are 260, as many threads being the width of a Brussels carpet which measures 27 inches. By the JACQUARD apparatus any particular thread may be drawn to the surface, and every colour employed in the production of the carpet must be brought to the surface in fixed places.

The method of forming a Brussels carpet is as follows:—The 'model' is usually one-tenth of the size that the pattern will be, and this is constructed upon paper ruled in lines in each direction, so as to form a series of squares. The ruled paper for Brussels carpet has 260 squares in its width, each square representing one thread or stitch. When the drawing on the lines is completed, the pattern is passed on to girls, who prepare the cards for the JACQUARD loom by stamping holes in them, so that the required threads may be brought to the surface when required. Any desired pattern may be produced by making the holes in certain positions, and there must be a frame of worsted in the loom for each colour that is requisite to the formation of the pattern.

The first seat of the Brussels carpet manufacture was at Wilton, but Kidderminster now supplies the largest quantity of such carpets. Bridgnorth, Halifax, and Glasgow manufacture them largely. The modern Wilton carpet is a Brussels carpet with a velvet pile (the loop being cut), instead of the ordinary looped pile. They are made in precisely the same manner as the Brussels carpet, only the wire frame is constructed of larger wires, so that the knife blade may more easily cut the loop.

An ingenious arrangement was made for the purpose of producing carpets, in which the JACQUARD apparatus was dispensed with. This method consists in printing a pattern upon the warp threads, these being arranged in a parallel series for the loom, and the dyes used must be such as penetrate the substance of the yarns. These are then woven into the fabric. It is said that this process is not satisfactory, as all the threads cannot be brought into their proper position, owing to small inequalities in their thicknesses.

Mr. WHYTOCK introduced a method by which this process could be used without employing a block for each colour. This process may be thus described:—

The pattern being produced on the ruled paper, is handed to the 'putter on,' who produces the necessary elongated pattern, so as to allow for the thickness of each thread. The pattern being properly produced, is cut vertically between each row of stitches. The patterns employed upon tapestry carpets are usually repeated in 684 stitches. A large drum has wound upon it an amount of yarn sufficient for the 684 stitches. On a railroad running beneath this drum is a wheeled trough, with a roller fixed in it like a grindstone, and into these troughs is poured the colours which will be required. The drum is made to rotate on its axis, and it rubs against the roller which is in, and which takes up the colour from the trough. Everything being properly adjusted, the yarn is regularly dyed by moving the drum and by adjusting the troughs, making the yarn take up the proper quantity of the desired colour.

Carpets are sometimes formed by weaving a plain fabric with the looped surface of a Brussels carpet, and then printing the pattern by blocks. This process is adopted in the Rochdale Works.

The TEMPLETON process, so called because it was introduced by the TEMPLETONS of Glasgow, is an improvement upon the WHYTOCK process already described, but it is said to be much more expensive.

Certain improvements have been made within the last few years. The hard back of the Brussels carpet has been set aside, and a soft back introduced by using a kind of felt.

Rugs.—By any of the processes named the ordinary rugs may be, and are, produced, although many rugs are still manufactured by hand in the most simple manner. A large number of rugs are made by the Axminster process. Some are formed by the true Axminster process, and are called thumb rugs, and others are produced by the tapestry process and by the velvet pile process.

The Messrs. CROSSLEYS, of Halifax, introduced some years since a method of manu

facturing rugs which was exceedingly ingenious and produced very beautiful effects. The pattern being selected, it was built up in threads of worsted, each thread being of the correct colour or shade of colour. These were laid in an iron frame, one upon the other, in long lengths, until eventually the whole of the picture was shown by the ends of the threads. Thus a block of worsted thread was produced several yards in length and of the size of the rug required. The end of the thread, the whole being pressed together, is cut smoothly down with a very sharp knife. A piece of canvas covered with a solution of india-rubber is pressed against the end, and allowed to remain in contact until all the threads are firmly fastened to this back. A knife then cuts of the required thickness of the pattern, and a rug of great beauty is at once produced. Another piece of prepared canvas is applied to the ends of the wool, and another rug produced, and so on to the end. Although very beautiful copies of pictures have been thus produced, the process has not been extended.

No return of the numbers of spinning spindles and power looms can be obtained later than 1874. In the *Miscellaneous Statistics* for that year the number of factories in the United Kingdom is given and the number of spindles used in spinning, weaving, and other processes. It appears that the members of the Chambers of Commerce in the spinning districts have stated their conviction that the returns published by the Government were not accurate, although these were compiled from Parliamentary papers; therefore, the publication has been discontinued. The following is the latest return:—

Return to House of Commons up to October 31, 1874—ordered to be printed August 6, 1875	Total Number of Spinning Spindles	Total Number of Doubling Spindles	Total Number of Power Looms	Total Number of Persons employed		
				Males	Females	Total Males and Females
England and Wales	2,125,890	291,560	75,591	53,996	77,835	131,830
Scotland . .	56,330	17,846	6,156	3,052	7,203	10,255
Ireland . . .	572	252	—	2	9	12
Grand total .	2,182,792	309,658	81,747	57,050	85,047	142,097
Bradford Chamber of Commerce Estimate, 1871	4,000,000		100,000	—	—	—

J. W. T.

Woollen Manufactures imported in 1875–76.

	1875		1876	
	Pieces	Value	Pieces	Value
Manufactures of Goats' Hair or Wool.				
From British India—				
Bombay and Scinde .	—	£46,026	—	£119,513
" other Countries .	—	5,028	—	11,358
Total . .	—	£51,054	—	£130,871
Cloths and Stuffs.				
From Germany . .	15,788	£77,690	14,178	£70,215
" Belgium . .	9,753	76,842	2,884	11,667
" France . .	246,903	1,158,041	281,747	1,243,104
" other Countries .	1,066	4,553	1,470	5,850
Total .	273,510	£1,318,026	313,178	£1,411,099

Woollen Manufactures imported in 1875–76—continued.

	1875		1876	
Unenumerated.	Pieces	Value	Pieces	Value
From Germany . .	—	£388,145	—	£142,203
„ Holland . .	—	374,021	—	465,08[illegible]
„ Belgium . .	—	182,895	—	154,0[illegible]9
„ France . .	—	1,919,518	—	2,279,01[illegible]
„ Turkey . .	—	62,912	—	86,386
„ United States of America . .	—	15,511	—	—
„ British East Indies	—	35,018	—	35,370
„ other Countries .	—	12,311	—	17,440
Total . .	—	£2,990,331	—	£3,509,612
	1877.			
Of Goats' Hair or Wool	—	£100,353	—	—
Of Wool other than Goats' Hair, &c.				
Cloths and stuffs . .	442,991	£1,912,660	—	—
Unenumerated . .	—	3,322,233	—	—

Woollen Exports.

	1875		1876	
Sheep and Lambs', British	Lb.	Value	Lb.	Value
To Russia . . .	702,080	£75,464	480,153	£44,219
„ Germany . .	2,994,750	300,701	2,767,276	2[illegible],773
„ Holland . . .	1,097,841	105,555	1,198,066	91,914
„ Belgium . . .	1,310,146	107,623	1,147,065	90,839
„ France . . .	3,062,629	236,284	1,589,444	130,803
„ United States—Atlantic . . .	1,164,673	82,721	2,434,958	144,295
„ other Countries .	204,504	19,846	199,358	21,929
Total . .	10,536,523	£928,264	9,817,319	£7[illegible]7,832
Other Sorts, including Foreign, dressed in the United Kingdom, and Flocks and Ragwool.				
To Russia . . .	2,505,500	£87,152	953,272	£[illegible],223
„ Sweden and Norway	626,260	27,535	563,047	28,479
„ Germany . .	4,163,525	131,805	2,833,397	90,411
„ Belgium . . .	1,216,450	21,358	599,230	14,659
„ France . . .	1,703,670	46,854	991,461	25,350
„ United States of America . .	1,005,807	30,783	—	—
„ other Countries .	205,147	7,587	503,615	18,612
Total . .	11,426,359	£353,074	6,444,112	£205,134

Woollen Exports—continued.

	1875		1876	
Woollen Yarn, carded.	Pieces	Value	Pieces	Value
To Germany	260,013	£42,186	179,013	£28,1[illegible]
" Holland	46,892	4,743	78,386	9,8[illegible]
" Belgium	44,614	6,309	68,377	9,098
" France	73,873	13,595	151,916	16,870
" Australia	36,833	6,193	39,580	5,990
" Brit. North America	41,633	5,687	41,958	6,344
" other Countries	81,238	11,403	93,050	12,903
Total	584,091	£90,116	622,610	£5[illegible],126
Worsted Yarn, combed.				
To Russia	2,316,400	£373,256	1,485,984	£216,175
" Sweden and Norway	328,572	47,714	479,765	64,521
" Germany	16,155,221	2,549,442	15,053,440	2,070,391
" Holland	9,993,175	1,637,264	10,627,552	1,569,121
" Belgium	435,591	63,519	428,221	62,549
" France	1,573,744	282,066	1,854,800	298,698
" other Countries	336,623	55,900	301,728	47,657
Total	31,139,626	£5,009,191	30,231,550	£4,328,115

Exports of Woollen and Worsted Manufactures.

	Year ended December 31			Year ended December 31		
	1875	1876	1877	1875	1876	1877
Woollen Cloths, Coatings, Duffels, &c., of all kinds of Wool, or of Wool mixed with other Materials.						
To Sweden and Norway	Yards 514,963	Yards 428,662	Yards 424,[illegible]	£ [illegible]	£ 71,262	£ 70,879
" Germany	9,484,276	9,714,[illegible]	8,713,[illegible]	1,820,[illegible]	1,[illegible]	1,292,477
" Holland	1,941,758	1,944,613	1,[illegible]	31[illegible]	[illegible]	2[illegible],934
" Belgium	1,216,266	1,874,084	1,430,[illegible]	[illegible]	264,840	2[illegible],224
" France	7,006,737	7,152,334	9,973,[illegible]	902,[illegible]	1,178,631	1,[illegible],232
" Portugal, Azores, and Madeira	211,171	1[illegible]	143,[illegible]	36,824	34,183	34,1[illegible]
" Italy	1,4[illegible]	1,[illegible]	1,442,[illegible]	[illegible]	2[illegible]	2[illegible]
" United States	3,612,810	1,4[illegible]	1,[illegible],000	7[illegible],114	4[illegible],918	8[illegible],349
" Brazil	1,4[illegible]	1,474,[illegible]	1,027,[illegible]	1[illegible],276	156,[illegible]	151,[illegible]
" Uruguay	342,1[illegible]	314,[illegible]	643,[illegible]	33,642	4[illegible]	77,1[illegible]
" Argentine Republic	[illegible]	4[illegible],800	917,[illegible]	6[illegible]	61,518	131,[illegible]
" Chili	463,870	[illegible],800	817,300	[illegible],652	4[illegible],349	5[illegible],702
" Peru	496,720	4[illegible],000	526,1[illegible]	[illegible]	[illegible],927	73,7[illegible]
" China and Hong Kong	1,887,000	2,376,220	2,414,800	242,971	2[illegible]	2[illegible],720
" Japan	242,100	319,740	819,[illegible]	[illegible]	43,607	1[illegible]
" British North America	3,785,575	2,[illegible],020	3,472,100	6[illegible]	474,[illegible]	[illegible]
" British India	2,490,190	2,239,017	2,413,900	2[illegible]	250,[illegible]	2[illegible]
" Australia	3,084,023	2,451,000	3,[illegible],600	5[illegible]	4[illegible],343	[illegible],467
" other Countries	3,045,041	3,[illegible]	3,1[illegible],000	505,[illegible]	516,15[illegible]	4[illegible]
All Wool yds. / lb.	15,606,033 / 13,183,687	15,535,306 / 13,847,203	16,549,700 / 14,767,900	3,193,275	3,202,[illegible]	3,227,[illegible]
Wool mixed with other Materials yds. / lb.	26,452,210 / 26,936,907	24,943,977 / 26,690,558	28,004,400 / 28,772,[illegible]	3,656,518	3,218,[illegible]	3,371,7[illegible]
Total yds. / lb.	42,058,281 / 40,120,584	40,479,273 / 40,048,[illegible]	44,554,100 / 43,[illegible]	6,[illegible],203	6,431,41[illegible]	6,[illegible],717

Exports of Woollen and Worsted Manufactures—continued.

	Year ended December 31			Year ended December 31		
	1875	1876	1877	1875	1876	1877
Worsted Stuffs, all Wool, or of Wool mixed with other Materials.	Yards	Yards	Yards	£	£	£
To Germany	37,097,800	27,448,[illegible]	17,129,[illegible]	1,512,[illegible]	1,371,514	[illegible]
„ Holland	16,548,570	11,181,049	9,804,500	621,388	[illegible]	[illegible]
„ Belgium	8,840,284	8,016,100	6,013,800	302,337	332,640	[illegible]
„ France	43,017,280	42,112,305	34,200,700	2,1[illegible],352	1,572,[illegible]	1,367,490
„ Italy	14,144,510	13,237,000	10,137,200	496,209	[illegible]	370,720
„ United States	51,258,290	41,076,020	22,967,400	2,276,166	1,347,120	1,170,[illegible]
„ China and Hong Kong	14,307,000	12,181,000	17,063,800	861,664	660,487	900,[illegible]
„ Japan	8,978,450	4,334,150	4,320,300	343,292	174,223	16[illegible],224
„ British North America	12,787,810	14,221,190	18,039,400	603,520	531,471	[illegible]33,087
„ British India	2,808,730	2,242,286	2,[illegible],500	120,210	106,040	104,[illegible]
„ Australia	11,334,342	16,317,190	16,251,000	544,404	662,0[illegible]	646,103
„ other Countries	81,[illegible]	28,083,[illegible]	25,904,800	1,374,421	1,217,873	1,062,861
Total: All Wool (yds.)	30,183,743	14,836,866	17,231,000	1,320,009	936,939	1,069,828
Total: All Wool (lb.)	7,709,755	5,570,090	7,110,900			
Total: Wool mixed with other Materials (yds.)	221,061,766	306,735,133	177,167,[illegible]	9,838,905	8,207,766	6,61[illegible],743
Total: Wool mixed with other Materials (lb.)	55,067,081	49,274,015	42,102,000			
Total: Total (yds.)	251,843,849	221,561,[illegible]	194,298,900	11,158,914	9,141,603	7,680,571
Total: Total (lb.)	62,586,789	55,044,635	49,213,900			
Blankets and Blanketing (yds.)	7,357,380	6,157,239	6,598,700	759,500	636,493	710,040
Blankets and Blanketing (lb.)	7,874,982	6,444,667	7,288,000			
Flannels (yds.)	8,552,427	7,744,763	9,264,900	451,137	408,287	846,432
Flannels (lb.)	3,016,431	2,778,740	3,080,[illegible]			
Carpets, not being Rugs.						
To Germany	430,446	364,264	44[illegible]	73,918	[illegible],838	70,778
„ Holland	339,718	370,[illegible]	300,200	50,262	59,000	58,174
„ France	826,707	824,618	860,700	123,583	107,830	108,440
„ Spain and Canaries	242,524	421,150	275,100	31,470	55,950	33,231
„ United States	2,138,150	1,013,000	616,400	367,777	175,308	88,1[illegible]
„ Chili	160,230	228,070	227,900	23,712	27,807	28,440
„ British North America	1,071,330	804,670	1,120,800	164,790	111,962	141,634
„ Australia	629,510	849,800	1,120,200	102,458	109,623	135,168
„ other Countries	1,422,021	1,384,723	1,490,000	226,744	198,106	159,207
Hosiery of Wool, or of Wool mixed with other Materials, yds.	7,222,860	6,298,479	6,457,900	1,150,979	911,973	842,464
Small Wares, unenumerated . yds.	11,901,822	9,770,800	9,900,600			
	—	—	—	914,644	279,068	294,183
	—	—	—	942,945	[illegible],643	736,200
Total of Woollen and Worsted Manufactures	—	—	—	21,489,235	18,808,478	17,334,[illegible]

The *Imports* of woollen and worsted manufactures in 1877 were as follows:—

	Lb.	Value
Woollen yarn for weaving	12,949,117	£1,540,157
WOOLLEN MANUFACTURES—		
Of goats' wool or hair	—	100,383
Cloth and stuffs (pieces)	442,901	1,012,660
Unenumerated	—	3,322,233

X

XANTHATES. (See XANTHINE, vol. iii. p. 1155.)

Xanthate of Potassium is easily separated by means of alcohol, potash and bisulphide of carbon. It crystallises easily, and may be kept in this state unaltered for a long time in well-corked bottles.

Xanthate of Copper forms a brilliant orange-yellow precipitate when xanthate of potassium is added to cupric salts.

Xanthate of Nickel forms a precipitate of a chocolate-brown colour, almost insoluble in water, exceedingly soluble in ammonia.

Xanthate of Cobalt is a dark-green precipitate, almost insoluble in ammonia, which circumstance allows it to be easily and rapidly detected in nickel solutions, and separated from nickel.

Xanthate of Zinc forms a brilliant white precipitate, very slightly soluble in water, much more so in alcohol and in sulphide of carbon, extremely soluble in ammonia.—T. L. PHIPSON, *Chemical News*, xxxv.

XYLOGRAPHY. A name given to a process of painting on wood. The commencement of the process is to draw on wood or on paper the pattern selected from which the design is transferred to wood. The design is then engraved or reproduced in zinc by a well-known method. An electrotype cast is taken from the woodcut or zinc plate, and smooth slabs of wood are printed from the electrotype under a regulated pressure, with pigments especially prepared. The wood where the pattern is, is slightly indented by the process. There is no outside film of colour. The dye has penetrated the wood. To preserve the material and enrich it the French polisher is called in, or the whole of the wood is covered with a fluid enamel which may be applied by an inexperienced person with a brush, and is serviceable for protecting any neighbouring pieces of metal, as well as the wood. The wood can be scrubbed, washed, and even sand-papered, without destroying the pattern. Xylography depends upon printing with movable blocks, and by placing different patterns side by side the effect of the whole may be varied at will.

Arabesques, tile patterns, and flowers are printed with movable blocks which can be collocated together in an infinite variety of ways. The completed series or group forms the ornament of a door-panel, the skirting for a room or a ceiling, a frieze or a border for any purpose, a line of decorations for the wall of a corridor. The method is very suitable for application to furniture, desks, workboxes, in cases where the expense of inlaying is prohibitive; and perhaps it is by this means that it will ultimately be employed. At present the results of the disposition of brown, black, russet, green, and grey-blue stains on sallow pine-wood are agreeable from novelty as well as from the taste with which the patterns are arranged. A door can by xylography be decorated in six panels at the cost of a guinea and a half in permanent colours with refined and intricate patterns, such as have hitherto been chiefly seen in the tail-pieces of gift-books. Most slabs are printed in one colour and by one impression, but tint can be applied over tint in exactly the same manner as in chromo-lithography.

Y

YELLOW-METAL SHEATHING. See MUNTZ'S METAL.

YELLOW WOOD. See FUSTIC, vol. ii. p. 527.

YERCUM NAR. (*Calotropis gigantea.*) When made into ropes this fibre has very great strength. See FIBRES.

YURAKU PORCELAIN. A Japanese china of a fine red colour. It was first introduced from China by ZENGORO YURAKU. The effective colour is heightened by rich gilding.

Z

ZINC. *Spelter Production in Missouri.*—The manufacture of metallic zinc or spelter, in Missouri, is carried on only at the establishments located at Carondelet, or South St. Louis.

Ores.—The ores treated at these establishments are brought, either by the Iron Mountain Railroad from the vicinity of Potosi, in the south-eastern part of the State, or by the Atlantic and Pacific Railroad from the mining regions of Newton and Jasper counties, in the south-western part of the state. They consist chiefly of

hydrous silicate, or calamine, with variable quantities of blende and some Smithsonite. At the localities mentioned the zinc ores have been rather the incidental products of lead mining than the objects of direct exploitation.

The erection of these zinc works and the prospective establishment of others, together with the utilisation of the blende ores of the south-west, at the establishments of La Salle, Ill., have created a rapidly increasing demand for such ores, till they now form no inconsiderable portion of the valuable production of the lead regions of Missouri.

No full analysis of the raw ore has been made, but various partial analyses seem to indicate that the ores from the south-west are much freer from antimony than those from the south-eastern section of the state. The presence of manganese in the ores from the latter section, and its almost total absence from those of the south-west, is noteworthy.

The ores of the south-east region, notwithstanding the presence of antimony and arsenic, are of a very fine quality, and compare closely and favourably with those from the well-known Saucon Valley, used at the Lehigh Zinc Works, Bethlehem, Pa.

The ores are roasted and calcined in kilns. Samples of the calcined ore, after crushing, gave on analysis the following composition:—

	I.	II.
Silicic acid	29·117	10·245
Zinc oxide	70·039	75·300
Ferric oxide	·527	2·014
Brown oxide manganese	none	1·642
Lime	·285	4·385
Magnesia	·084	3·320
Arsenious acid	·540	trace
Antimonic oxide	trace	·280
Lead and copper oxides	trace	trace
Sulphur	·349	trace
Carbonic acid	trace	3·320

No. I. is the roasted ore used at the Martindale Works, and is chiefly furnished by the Granby mines.

No. II. is a mixture of the ores from the two sections of the state, the south-western ores predominating.

The retorts are of the usual form used in the Belgian process; they are 4 ft. in length by 6½ in. interior and 9½ in. exterior diameter.

The capacity of the single furnaces at the Martindale Works varies from eighty to eighty-eight retorts. Those at the Missouri Works contain seventy four. There are eight furnaces in operation at the former establishment, and six at the latter, giving a joint capacity of upwards of eleven hundred retorts.

The Lehigh furnaces hold each fifty-six retorts, besides the so-called "cannons" for breaking the heat in the lower row.

The retorts are charged each with 40 lb. of a mixture consisting of two-thirds ore and one-third slack.

The methods of working offer no novel features. A retort lasts about a fortnight, or through twenty-eight charges. The upper row of retorts is reserved for the treatment of the zinc dust, drippings, and skimmings. The dust used at Bethlehem contains from 60 to 65 per cent. of metallic zinc, while at Martindale they get 75·8 per cent.

The following analyses show the composition of various spelters:—

	I.	II.	III.	IV.	V.
Sulphur	·0035	·0741	·0020	—	—
Silica	·1316	·1374	·2410	—	—
Carbon	·1775	·0006	·2322	·0036 to ·75	—
Iron	·7173	·2863	1·0342	·28 „ ·32	1·5
Lead	·0701	·0061	·1004	·47 „ ·15	·8
Copper	·1123	·0018	·0868	—	—
Arsenic	·0603	·0590	·0806	—	—
Antimony	·0249	·0000	·0000	—	—
Cadmium	—	—	—	·97	—
Impurities	1·3005	·5653	1·7852	—	—
Zinc	98·6095	99·13723	98·2118	—	—

No. I. is the analysis of the MISSOURI ZINC COMPANY's spelter; No. II. of the Martindale spelter; and No. III. of a specimen of Lehigh spelter. From what character of ore No. III. was prepared is not known. Nos. IV. and V. are older analyses of spelter (by PLATTNER) from Silesian and Chinese specimens respectively.—*Process of Spelter Production as practised at Carondelet, Missouri, with Comparison*, by JOHN W. PAGE.—*Transactions of the American Institute of Mining Engineers*, vol. iv.

ZINC, SILESIA. *The Present Condition of the Zinc Industry of Upper Silesia.*—The ores treated for zinc in Upper Silesia are of two classes; namely, calamine averaging from 11 to 15 per cent., and blende with from 25 to 30 per cent. of zinc. The former are calcined in the usual way (? in kilns), and the sulphuretted ores in double-bed calciners (Fortschaufelungsöfen), except in one establishment near Schoppinitz, where HASENCLEVER's patent furnace is used. Ordinarily the calciners are erected in blocks of four, having chimney flues and passages for drawing the roasted ore in common, in order to economise space. The HASENCLEVER furnace has a step-grate fire-place, and with a consumption of 40 cwt. of coal slack in 24 hours, produces 70 cwt. of calcined blende, not containing more than 1 per cent. of sulphur. The ore, which is fed continuously by a small water-wheel, must be reduced to particles of 3 millimètres in diameter and free from dust; if they are of larger grain the roasting cannot be effected, and if smaller they will not travel freely down the incline of the bed. For the flat calciners a grain of about 2 millimètres is found to be the most convenient size. It is therefore necessary to prepare the ore for the patent furnace by a system of rock breakers and coarse and fine crushing rolls; while for the ordinary furnaces it is ground under edge mills.

The working beds of the double calciners do not exceed 7·2 ft. in breadth, while the length varies from 18 ft. to 25 ft. Increased length has the advantage of more fully economising the heating power of the fuel, but makes the furnace difficult for one man to manage, so that the roasting may be only imperfectly effected. As a rule it is not considered desirable to employ a special fireman, the heat being better under control when the entire management of the furnace is in the hands of one man. The average yield of each calciner is from 60 to 64 cwt. of calcined blende per 24 hours, with a maximum of 1 per cent. of sulphur for a consumption of 30 cwt. of coal. The progress of the calcination is in some works controlled by the following simple test:—A sample of the charge is strewed upon the surface of 20 or 30 grains of chlorate of potash melted in an iron ladle, when if no flash of burning sulphur is produced, the ore is considered sufficiently desulphurised.

Calamine ores, as mixed for reduction, do not as a rule contain more than 14 per cent. of zinc. The blende, which is usually very pyritic, is richer, and is added in sufficient proportion to bring up the produce; in this way very poor calamines, containing only 7 to 9 per cent. of zinc, are worked up. Mixed coal slack and cinders are used for reduction; from 3 to 3½ bushels of the former and 5½ to 6 bushels of the latter being required per 100 cwt. of calamine. With pure blende the quantity is increased about 11 per cent., partly on account of the greater difficulty of reduction, but more particularly to protect the muffle against increased corrosion.

The cinders are small particles of coke breeze obtained from the fire-places of the puddling and heating furnaces in the neighbouring iron works, where they are collected in water cisterns placed in the ash-pits. They play but a very subordinate part in the reduction of the zinc oxide, being almost incombustible; their chief function being to prevent the formation of easily fusible slags by the action of the iron in the ore upon the substance of the muffle. The weight of the charge varies with the richness of the ore in zinc; with blende it is usually only half that of calamine. In the larger-sized muffles about 230 lb. of calamine with 11 to 12 per cent. of zinc is a usual quantity.

The muffles vary in size according to their position in the furnace; the following being the limiting dimensions:—

	Fore End	Back End
Length		5·2 ft. to 6·0 ft.
Height	13·7 in. to 21·6 in.	23·2 in. to 24 in.
Breadth	6·0 „ 7·8 „	8·7 „ 10·6 in.

The length is governed by the heating power of the furnace, shorter sizes being used in the cooler parts, or in the last stages of its working, before being rebuilt; while the height depends upon the fire-resisting power of the clays; and the breadth upon the comparative reductibility of the ore. The materials are lean (sandy) clays from Galicia, plastic clays from Silesia and Poland, and sherds of old muffles ground under edge rolls to fragments 8 or 10 millimètres in diameter. The ordinary mixture is 3 parts of burnt to 2 of lean and 1 of plastic clay. The moulding is effected by

hand, the sides being raised from sheets of clay over wooden cores. Generally four or five muffles are kept in hand by the same man at once, so as to save time and to insure uniformity in drying. When finished they are air-dried for at least 14 days, and before setting are raised to a bright red heat in a tempering oven for 12 or 14 hours. These are ovens of sufficient capacity to take from 16 to 24 muffles, to supply a demand caused by excessive breakages, &c. The average life of a muffle is from 35 to 36 days, each one being numbered and marked by the maker, who, in the event of his work giving out too soon, is liable to a fine. From 20 to 24 muffles are moulded by one man in 6 working days, the clay mass being supplied by the works. The receivers for the reduced zinc are made of ordinary potters' clay mixed with a small quantity of burnt clay or coke dust, and they continue in use until the incrustation of zinc oxide prevents the introduction of the charging shovel, which usually takes place in from two to three weeks. They are made by the smelters themselves, the mixed clay being supplied by the works.

Between the years 1860 and 1872, twenty-nine of the existing Silesian zinc works were closed, and from 1844 to 1873 eleven, and in 1876 two new ones were built. At the present time twenty-nine are at work; of these, eleven are provided with furnaces with plain grate firing after the old Silesian pattern. In the newer works, however, gas furnaces are invariably employed. Owing to the dry character of the coal it is necessary for complete gasification to burn it by means of a weak blast, which is, in the larger number of instances, produced by a fan, but in the newer furnaces generally by Körting's steam-jet blower. The blast is introduced immediately below the grate in the gas-producer by a cast-iron mouthpiece of square section; that required for combustion of the gas is supplied through a series of twelve rectangular slits in the mouthpiece of the gas supply passage, which is a square shaft of firebrick work. The number of muffles in a furnace of this kind varies from twenty to twenty-eight, with the gas burner at one end, but in some instances double furnaces with two gas-producers are arranged in two parallel series and twice that number of muffles are used, with the points of combustion placed equidistant from the end walls. These have the advantage of more perfectly heating the end muffles, of diminishing the amount of radiating surface, and generally the cost of labour and supervision, but they require much greater skill in management, especially to prevent loss in the event of defective working; besides which, an increase in the number of muffles is attended with loss of time during cleaning, charging, &c., so that the reducing work of the furnace may be actually diminished if the number is too great. Experience shows that the maximum should not exceed forty, the best results being got with thirty-two. The waste flame of the older grate-fired furnaces is sometimes used for calcining calamine, and in a few instances for heating the air for combustion of the gas. Only in one instance (at Tarnowitz) is a regular iron pipe stove used.

The above conditions limiting the size of the furnaces do not, however, apply to those on Siemens' principle, where, from the greater uniformity of temperature obtained in the heating chamber, a larger number of muffles can be heated than in the common gas furnace. In addition to the saving in coal, wages, and distilling vessels, due to these causes, the duration of the working period of the furnace is considerably longer, being for furnaces of equal size, two years as against one year and a half. Against this, however, must be set the increased cost of erection, more than 50 per cent., and consumption of fire-clay, difficulty of management with unskilled workmen, and, more particularly, the necessity of rich gas-making coal, which render its use improper for localities where the coal is of an anthracitic character. Where, however the proper conditions are fulfilled, there is a notable advantage in the use of the furnaces, as appears by the following comparison made upon the working of the year 1874:—

	Ordinary Furnace, 24 muffles	Siemens' Furnace, 54 muffles
Ore worked per 24 hours	35·14 cwt.	108·27 cwt.
Consumption per 5 tons of ore:—		
Coal	54 quarters	33·8 quarters.
Muffles	1·75	1·42
Yield per cent. on ore	11·17 per cent.	11·39 per cent.
Cost per cwt. of zinc for wages, ore, materials, tools, and repairs	18*s.* 1½*d.*	16*s.* 5*d.*

In the works last built, four furnaces, with sixty muffles each, with two double gas-producers, have been provided.

The working and management of the furnaces are described in considerable detail by the author, the chief points of interest being in the method adopted for detecting broken muffles. In furnaces heated by gas under pressure, the cracks in the muffle

are seen by the entry of the furnace flame, which alters the blue flame issuing from the mouth of the zinc receiver to a brownish red; while in SIEMENS' furnaces, where there is a chimney draught, air is drawn through the muffle and zinc flame appears in the chimney. Flaws in the roof of the muffle are seen by the issuing of zinc flame, as soon as the receivers are adapted after charging. These cannot be repaired unless they stop themselves by deposit of zinc oxide in the apertures. Holes in the bottom of the muffles are detected after clearing out the residue of the preceding charge, by producing a body of luminous flame in the fire-place, either by the sudden addition of coal in grate furnaces, or by stopping off the top-blast in gas and SIEMENS' furnaces, which then finds its way through the cracks. These may often be repaired by plastering the surface with tempered clay, but large cracks in the roof render a shifting of the muffle necessary.

The yield of zinc is from 62 to 75 per cent. of that indicated by analysis of the ore. As a rule it is sold as produced, but in some instances it is refined to render it fit for rolling, by remelting in a reverberatory furnace with a bed 15½ ft. long, 6½ ft. broad, and inclined 3° longitudinally from the bridge towards the flue end, where there is a pit about 2 ft. deep below the lading hole. The flame is kept as smoky as possible, and returns by a double arch above the bed to the chimney, in order to protect the furnace from loss of heat by radiation. About 9 tons of crude zinc are treated daily, and the original proportion of 2½ per cent. of lead is reduced to ½ per cent., the loss in skimmings being 0·15 per cent.

The zinc dust (oxide of zinc) collected from the receivers, &c., is returned to the ordinary charges, except when there is a special demand for it, when it is sold. In some instances cadmium is prepared from it by a process of fractional distillation, but there is not sufficient call for this metal to render its production generally profitable at the present time.—MAX GEORGI, *Berg- und Hüttenmännische Zeitung*, vol. xxxvi. pp. 71, 78, and 97.

On the Zinc Ore Deposit of Moresnet (Vieille Montagne).—The deposit of calamine of the Vieille Montagne, Altenberg, or Kelmisberg, as it is variously styled, occurs in the lowest portion of the carboniferous limestone, which is here generally changed into dolomite. Its form is that of a basin, or the bottom of a boat, rising on one side to the surface, and plunging on the other at an angle of 15°, the greatest breadth being about 650 yards. The ore, which at the surface was composed principally of carbonate of zinc of extreme purity and richness, being entirely free from lead and blende, is intimately associated with dolomite, and must be considered as a pseudomorphous change of the entire mass of a limestone or dolomite bed into carbonate of zinc, and not as a deposit of secondary origin, like many of those in the neighbourhood.

The principal development of the deposit was near the surface, where it may have attained a length of 490 yards, and a breadth of between 110 and 160 yards, the whole space occupied by the basin having been filled with metalliferous matter. The largest and richest portion is near the northern extremity; this is known as the North Deposit, and is separated by a tongue of barren dolomite from another ore-bearing portion known as the South Deposit. In a south-west direction, the ore-band plunges below the dolomite, and has been proved to a depth of 120 yards, between which level and that at 80 yards the workings are now restricted.

A considerable change takes place in the character of the ore in depth, the pure carbonates of the surface becoming mixed with hydrated silicates, until at a depth of 80 to 90 yards the latter predominate. The anhydrous silicate, or Willemite, one of the distinguishing peculiarities of Vieille Montagne, was found irregularly interspersed in large blocks, often exceeding 100 cubic yards in volume, in the mixed masses of calamine. The first workings seem to date from the fourteenth and fifteenth centuries, when the rich ore of the north crop was used by the brassmakers of Stolberg, and probably of Liége, in the manufacture of calamine brass. The first zinc furnace was established at Liége in 1809 by the Abbé DONY, who held the concession for working calamine for a term of years; but the amount of ore removed was not large, only the most compact and richest portions being taken, the earthy and less valuable qualities being left. It was not until 1846, under the VIEILLE MONTAGNE COMPANY, that the development of the workings was commenced, which ten years later reached colossal proportions. The production in 1855 was probably the largest. —O. BILLAY, *Revue Universelle des Mines*, vol. xl. pp. 235–39. *Abstracts of Papers in Foreign Transactions, Institution of Civil Engineers.*

ZINC IN CANADA.—Zinc ores have been obtained from Blende Lake, near Thunder Bay, Lake Superior, from the township of Dorion, from the Parresseux Rapids, Kaministiquia River from Silver Lake in Thunder Bay, and Pointe-aux Mines.

In addition to the above localities for zinc blende on Lake Superior, it may be mentioned that the mineral occurs in greater or less abundance in almost every metal-

tiferous vein which has been opened in the rocks of the Nipigon Series, from Pigeon River to Nipigon Bay. Further east it occurs in promising quantities in a vein in older rocks between Otter Head and Michipicoten, and again in veins in the copper-bearing series at Pointe-aux-Mines and Mamainse. (See *Reports of the Geological Survey* 1863 to 1873.)

PRUSSIA. *Zinc Ores produced.*—At page 586 the mineral productions of Prussia from 1871 to 1875 will be found, and the values of the minerals raised. The following table is given in addition, as it shows the quantity of zinc ores (calamine and blende) raised in the different districts. This return is for 1873, the latest detailed return available. Relatively, the variations between the production of the several districts have been unimportant.

Zinc produced in Prussia in 1873.

Provinces	Weights of Ores extracted			
	Calamine	Blende	Total	Value per Tonne
	Tonnes of 984 lb.	Tonnes of 984 lb.	Tonnes of 984 lb.	Francs
Silesia	361,355	5,071	366,426	30.45
Hanover	—	3,862	3,862	156.02
Westphalia	22,169	12,681	24,850	41.23
Hesse Nassau . . .	335	8,186	8,521	62.36
Rhine Provinces . .	303	27,659	27,952	63.55
Total and mean . .	384,252	57,359	441,611	35.10
Production, 1872 .	355,653	56,162	441,815	25.77
Increase . . .	28,599	1,197	29,796	9.33

—*Zeitschrift für das Berg-, Hütten-, und Salinen-Wesen im Preussischen Staate*, vol xxii., 1874.

UNITED KINGDOM, *Zinc Mines of the. Production for the Years* 1875 *and* 1876.

Counties, &c.	1875			1876		
	No. of Mines	Quantities	Value	No. of Mines	Quantities	Value
ENGLAND:		Tons cwt. qrs.	£ s. d.		Tons cwt. qrs.	£ s. d.
Cornwall . . .	6	2,060 19 3	6,456 18 10	14	4,413 9 2	14,292 19 9
Cumberland and Northumberland . .	9	1,060 13 0	5,424 0 0	—	—	—
Cumberland . .	—	—	—	6	1,366 2 2	5,000 0 0
Derbyshire . . .	—	160 0 0	300 0 0	1	51 6 1	158 18 0
Shropshire . . .	5	830 12 0	2,652 0 0	5	491 10 0	2,670 0 0
Yorkshire . . .	—	—	—	1	3 10 2	10 11 8
WALES:						
Anglesea . . .	—	—	—	1	7 0 0	8 7 0
Cardiganshire . .	6	60 4 2	153 0 0	8	212 8 0	1,018 12 0
Carnarvonshire . .	4	414 0 0	1,344 15 0	5	360 8 2	1,480 17 0
Denbighshire . .	3	1,920 0 0	8,173 11 3	8	3,163 0 0	11,608 12 0
Flintshire . . .	3	1,349 17 0	6,664 0 0	4	2,494 10 0	12,084 2 3
Montgomeryshire .	4	2,230 16 0	4,599 14 1	4	2,760 15 0	10,040 1 0
Radnorshire . .	1	48 14 0	246 2 10	1	69 5 0	278 13 1
Sundries, England and Wales . . .	—	170 0 0	690 0 0	—	176 0 0	588 16 0
ISLE OF MAN . .	4	11,598 0 0	35,085 0 0	3	8,005 5 0	27,033 1 8
SCOTLAND . . .	1	62 12 3	362 1 1	1	345 0 0	1,708 0 0
Total . .	43	22,079 8 3	75,110 3 7	57	23,873 8 1	90,142 0 8

IMPORTS AND EXPORTS (AS PER BOARD OF TRADE RETURNS).

Imports of Zinc in the Year 1876 and Five previous Years.

Year	Crude Zinc		Zinc Manufactures	
	Quantities	Value	Quantities	Value
	Tons	£	Tons	£
1871	20,968	431,309	6,792	207,855
1872	14,874	302,320	12,417	340,827
1873	20,938	478,625	12,470	367,935
1874	22,216	492,874	12,630	372,176
1875	22,719	513,457	15,276	439,548
1876	29,466	666,234	19,719	411,536

Exports of British Zinc or Spelter in the Year 1876 and previous Years.

Year	Quantities	Value
	Tons	£
1871	6,452	115,281
1872	6,017	101,812
1873	3,440	85,746
1874	3,792	94,490
1875	4,896	116,588
1876	5,656	130,206

In 1877 we imported zinc (crude and in cakes) 35,094 tons, and manufactured zinc 322,056 cwt.

ZINC, *Desilverising Lead by.*—In vol. iii. p. 70 will be found a description of PARKES's process of desilverising lead by zinc. This process has not held its ground in this country, but in Germany it has continued in operation, as it appears, with considerable advantage.

In STUMMER's *Ingenieur* we find a full description, with drawings, of the latest development of this process, as carried out at the Imperial smelting works at Tarnowitz, in Silesia, which is thus described by my friend, Dr. WEDDING:—

ZINC FURNACE *for the Distillation of Zinc combined with Lead (Zinkbleiofen) at Tarnowitz, Upper Silesia.*—This is an addition to the contrivances for treating the argentiferous zinc obtained in desilverising lead by PARKES's process, which consists in adding melted zinc to the lead under treatment. The metals are stirred and allowed to separate, when the specifically lighter zinc rising to the surface, carries with it nearly the whole of the silver, and is removed by skimming. The impoverished lead is subsequently refined for market by various processes. When the zinc skimmings are subjected to liquation, a considerable quantity of argentiferous lead separates, while the zinc is to a great extent oxidised, producing the so-called zinc dust. This is subjected to distillation with carbon in muffle furnaces of the Silesian pattern, and produces zinc practically free from silver; the various residual products contain the whole of the silver. These are either sent directly to the cupellation furnace, or added to a bath of furnace lead, with a view of enriching the latter up to cupellation point. The furnace to be noticed is intended for the last operation, namely, the distillation of the zinc skimmings. The chief peculiarity is in the construction of the muffles, which are made of fire-clay containing a very small proportion of silica. They are prepared by being lined with a layer of gas-retort carbon, such as is obtained in coking the Zrabze coal, which is practically an incombustible material. This carbon, obtained in a finely-divided state by sifting through a sieve of 0·37 inch mesh, is mixed with finely-ground fire-clay, and moistened with a weak acetic acid solution of equal parts of strong vinegar and water, so that the peroxide of iron resulting from the oxidation of the pyrites in the coal may be distributed through the mass, and the possibility of local fusion be prevented. Salt is added to the solution, the purpose of the salt and clay being to cause the mass to unite when heated. The bottom and end of the muffle are covered with a layer of this material about 1 inch in thickness, the sides and roof receiving a thinner coating. After drying for a fortnight in a temperature of about 60° Fahr., the muffles are removed to a warmer floor, where during six weeks the temperature is gradually raised to 85° or 90° Fahr.

When thoroughly dried, the lining is covered with a glaze formed of lead smoke from the condensing chambers, which contains about 55 per cent. of lead, mixed with about one-third of its weight of clay containing about 66 per cent. of silica. These are mixed to a thin paste with water, and applied with a whitewasher's brush.

When required for use, the muffle so prepared is taken to the tempering oven, and in about three days is brought to a red heat. The glaze then melts, and any easily-combustible portion of carbon that may be contained in the lining is thereby protected from oxidation. The muffle is finally taken to the zinc furnace upon a two-wheeled bogie, and set in the arch in the usual way.

The charge consists of zinc skimmings, carefully separated by sifting from shots of metal, mixed with half the weight of cinders or breeze from the ashpits of the lead furnace, and pieces of coal of a size to pass through ¼ inch to ½ inch ring, with a cover of the oxide of zinc skimmed from the surface of the zinc obtained in the distillation. The charge of each muffle is 137·5 lb. of argentiferous zinc dust, with 68·7 lb. of cinders. The condensers are inclined D-shaped clay tubes, with a sheet-iron receptacle for fume in front, in which the zinc is collected in the usual way. The distillation lasts twenty-four hours; during the first three cadmiferous fume is collected in the iron receivers and put on one side. On the next day the zinc is removed from the tubes, and the whole of the lead and silver is found interspersed in globules through the residua in the muffle, which are drawn forward to the front of the furnace and worked over twice with an iron scraper, to make the globules unite and run into a ladle. The lead so obtained contains about 2·5 per cent. of silver; a further quantity is collected at the bottom of the waggon in which the residua are removed, and goes to the next day's collection. When cold the residues are sifted, and the finer material, which contains 61 per cent. of lead and about 1·8 per cent. of silver, is added in quantities of 4 tons to 20 tons of ore furnace lead, melted in a large pot, which is thereby sufficiently enriched to be capable of direct cupellation. The small quantity of residuum not dissolved in this process is mixed with lime, and treated in the ore- and slag-smelting furnaces. The coarse residua from the sifting, consisting mainly of cinders saturated with zinc and lead, go back to the distillation furnaces.

The furnace is fired by gases produced from coal in a special generator, with a step grate and a blast in the ash-pit. They are burnt by a blast of air heated in a syphon-pipe heating stove by the waste flame. The complete furnace, consisting of two divisions of twenty-four muffles each, consumes 88 cwt. of coal per day, besides 5 cwt. employed in working the fan-blowers.

When a muffle becomes leaky, which is known by the reddish colour of the flame from the nozzle, the last charge before removal is formed of zinc oxide containing lead, but free from silver, in order to clear out the argentiferous lead, absorbed by the lining. The muffles generally last about twenty weeks. The chief point to be attended to is to conduct the operation at as low a temperature as possible, in order to prevent loss of lead; the residues, therefore, are removed while still containing from 1 to 2 per cent. of zinc.

Experiments on the same process conducted in graphite muffles, such as are stated to be used for the same purpose in North America, did not give results as favourable as when clay muffles lined with carbon were used.—Dr. WEDDING, *Zeitschrift für das Berg-, Hütten-, und Salinen-Wesen*, xxii. parts 3 and 4. pp. 170–179. *Abstracts of Papers, Institution of Civil Engineers.*

ZINC. *Silver Lead Alloy.*—Mr. A. EILERS, of New York City, has communicated to the *Transactions of the American Mining Engineers* an excellent paper on the American method of treating by distillation the zinc-silver lead alloy obtained in the desilverisation of lead. From this we obtain the following:—

In extracting the silver from work-lead by means of zinc, it is always the intention, in this country, to obtain a zinc crust so rich in silver that the rich lead resulting from subsequent distillation contains from 5 to 10 per cent. of silver, or even more. Where the ordinary work-lead of the Western smelting works, containing from 100 to 400 ozs. of silver per ton is treated, from 1·4 to 3 per cent. of zinc is used, and it is only necessary to use the second and third additions of zinc again in a subsequent operation, as addition No. 1, in order to bring them up to the required standard, the No. 1 of the first operation being already rich enough for the purpose contemplated. When poorer work-lead is treated (which, by the way, does not often occur), the same object is reached by the repeated use of the No. 1 zinc addition, as above mentioned, in regard to additions 2 and 3 of the ordinary process. One object in making the zinc crust so rich in silver is to render it less liable to oxidation in the following liquation; another, to shorten and, therefore, cheapen the distillation itself.

The rich zinc crust is liquated, at some works in reverberatories, at others in kettles standing for that purpose near the large desilverisation kettles. It is, however, always the aim, *not to produce any oxides*, and for that reason the temperature is kept exceedingly low, and access of air is limited as much as possible. In this fact lies

the fundamental difference between our American distillation and that at Tarnowitz. In carrying liquation not nearly so far, and therefore not producing any oxides, we get rid at once of an immense amount of work, which the oxides formed at Tarnowitz occasion; and our immediate product of silver reaches, in consequence, a far higher percentage.

The liquated zinc crust was subjected to distillation before 1870 by Mr. BALBACH, of Newark, but the process was at that time very expensive, in consequence of the frequent breaking of retorts, which cost from $14 to $16 a-piece. The retorts then used were made of the same material and of the same shape as those used to-day. They are made of New Jersey clay and chamotte, and contain about 25 per cent. of plumbago. But at that time the neck of the retort had to be freed from the surrounding brick, and lowered every time at the end of a distillation, and this handling of the retort, while white hot, caused frequent breakage. This most serious objection to the process was, however, removed in 1870 by the invention of Mr. A. FABER DU FAUR's tilting retort furnace, which has since been introduced in the majority of works in this country.

The process of distillation now is as follows:—

The retort furnace is heated by means of coke (at one works in the West crude petroleum is said to have been used instead of coke—this is probably so far advantageous, as thereby the formation of slag accretions on the outside of the retort is prevented) until the retort has become dark red. Then it is charged by means of a small copper shovel with liquated zinc-crust, which has previously been subjected to granulation. According to the richness of the alloy, and the size of the retort, a charge filling the retort to the neck consists of from 250 to 400 lb. of alloy, with which from 3 to 5 lb. of small charcoal of bean to nut size have been mixed. Next, the condenser is put on; this may either be made for the purpose, being in that case simply a truncated cone of fire-clay, about 2 ft. long and of an inside diameter at the base a little larger than the outside diameter of the retort; or it may be an old retort, which it is unsafe to expose to the white heat required for distillation, and which is thus made to do duty for a while longer. The temperature is then at once raised to *white heat*, and kept so until the distillation is complete. The operation lasts from 8 to 10 hours, according to the percentage of zinc in the alloy. During all this time it is only necessary to keep the retort uniformly at a white heat. If this is neglected, a crust of chilled alloy is apt to form on top of the metal-bath, which, upon a renewed raising of the temperature, would cause an explosion in consequence of zinc-fumes suddenly developed under the crust. An occasional introduction of a small iron rod into the retort through the condenser serves to show the workman whether he has kept the temperature high enough. Experienced men never make a mistake in this respect. The metallic zinc, collecting in the condenser, and retained there by a rim of blue powder and oxide of zinc, forming around the mouth, is from time to time tapped, and the blue powder and oxide are quickly scraped into iron vessels, from which the air can be excluded, the object being to prevent the oxidation of the blue powder. When sufficient metallic zinc has thus been collected, it is remelted in a kettle under a coal covering; the oxide and impurities are taken off, and the metal is cast into plates, which are again used for desilverisation. From 40 to 50 per cent., and sometimes more, of the zinc originally added to the work-lead, is thus regained in the form of plates, which contain only a trace of silver. The blue powder and oxide containing no more silver than the metal, and comprising about 10 to 20 per cent. of the original zinc, are sold to zinc works. Thus about 50 to 70 per cent. of the original zinc is obtained again, the remainder having been partly retained by the desilverised lead, the contents of which in all cases amount to the somewhat constant figures of 0·7 to 0·8 per cent. of zinc to the whole mass of lead, and partly lost as oxide escaping from the mouth of the condenser.

When, in spite of a continued white heat, the zinc vapours are developed only very sparingly, the process is carried as far as policy permits, the rich lead containing then still a trace of zinc. At the same time it is desired that the zinc contents of the rich lead should not be more than a trace, in order that serious losses from this cause may be avoided in the subsequent cupellation. The condenser is then taken off, so that the zinc fumes, still in the retort, may more readily escape, and the furnace is left to itself for a few minutes. Meanwhile a small two-wheeled waggon, carrying a cast-iron pot, lined with moulder's sand of the iron-casting houses, is brought in front of the retort, and by tilting the whole furnace the rich lead is transferred in a stream to the kettle. After having here cooled awhile, the metal is poured into lead moulds, previously washed inside with lime milk, and well warmed. These moulds are only half filled, in order to produce thin bars, which are handier afterwards for gradual addition on the English cupelling hearth. The residue remaining in the retort after the discharge of the rich lead, and consisting of a little charcoal and slag, is scraped out with an iron hook, while the retort is yet tilted. The larger pieces of coal go

back into the retort in the next distillation. The small stuff and slag is kept separate, and is afterwards added in the smelting, in which the rich litharge is reduced, or sometimes it is immersed in poor lead. The entire quantity produced during any one distillation should, after sifting out the large coal, not weigh over a pound or two. If no dust or dirt has been allowed to get into the alloy before distillation, and if the temperature has been kept high enough during that process, including the discharge of the retort, the remaining scraps will always be found insignificant.

A handful of fine charcoal-dust is now thrown into the discharged retort, the object being to prevent the oxidation of small lead globules, because litharge once formed would soon destroy the retort. Next, the furnace is turned back to its original position, the grate is cleaned, accretions of melted ashes, which may have formed on the sides, are broken off, there is new coke added, and the retort is at once filled with a new charge. A retort lasts now from 15 to 30, or on an average for about 20 distillations—the retorts becoming unserviceable principally on account of accretions on the outside, which are melted coke ashes. To obviate this, firing with crude petroleum, and flame-fire from gas-generators, have been proposed. Both ways are, no doubt, practicable, and the latter especially may result in a large saving in fuel.

The following are the results of two campaigns of the Pennsylvania Lead Company at Pittsburgh, as described by Mr. E. F. Eurich, the metallurgist and superintendent of the works. In one of these, unrefined work-lead, as it comes from the shaft furnace of the company, was treated; in the other, work-lead refined before melting it down in the desilverisation kettle.

I.—Desilverisation of Work-Lead direct from the Shaft Furnace.

	Lb.	
To the kettle: Impure work-lead	87,294	
Taken off: 'Schlicker' (cuprous oxide)	3,497	
Remains: Pure work-lead	83,797	Silver ozs with 6,305·6
To this was added: Zinc	1,760	= 2·1 per cent.
The zinc-crust after liquation was	9,525	
'Abstrich' from dezincation of poor lead	7,810	
Oxides and metallic lead from market-kettle	1,000	
Lead from liquation of zinc-crust	808	
Market-lead	67,104	

Distillation of Liquated Zinc-crust.

The liquated zinc-crust was subjected to distillation in twenty-seven charges. Average charge 353 lb. of alloy, with 3 to 4 lb. of small charcoal. In 24 hours two distillations were effected in each retort.

		Lb.
Charged:	Liquated zinc-crusts	9,525
	Charcoal	108
Result:	Rich lead	7,609
	Metallic scraps	390
	Charcoal, with little metal	not weighed
	Metallic zinc	770
	Blue powder and oxide	not weighed

Coke used: 410·4 bushels @ 40 lb. = 1·7 lb. per lb. of zinc-crust.

The metallic scraps were immersed in poor lead on the cupelling test, and then cupelling was continued in the usual way, by adding rich lead bars from time to time. By the immersion of the scraps in poor lead, 230 ozs. of silver were extracted from them.

Results.

1. *Control of Silver.*

	Ozs.	Ozs.
In refined work-lead		6305·6
Obtained and proved:—		
Silver tapped from test, 6,098·75 ozs. @ ·989 fine	6031·66	
Small pieces of silver from test, 150 ozs @ ·970 fine	146·50	
Directly obtained, silver	6178·16	
Silver in market-lead, 0·33 ozs. per ton in 67,104 lb.	11·18	
		6189·34

	Ozs.
This leaves in litharge, hearth, retort-scraps, oxides, and scum from immersion, and liquation lead	116·26
	6305·6

And the direct product of silver is 98·1 per cent.

2. Control of Lead.

		Lb.
Unrefined work-lead		87,294
Obtained and accounted for :—	Lb.	
'Schlicker' 3,497 lb. at 80 per cent.	2,797	
Lead in zinc-crust	7,765	
Soft market-lead	67,104	
Oxide and scum from market-kettle, 1,000 lb. at 95 per cent.	950	
Liquation lead	808	
Oxides from dezincation, 7,810 lb. at 80 per cent	6,248	
		85,672
Loss, about 1·9 per cent		1,623

II. Desilverisation of Refined Work-Lead.

	Lb.
To the kettle: Lead	62,895 with silver, 6,165·9 ozs.
Added: Zinc	1,360
Produced: Liquated zinc-crust	6,362
'Abstrich' from dezincation of poor lead	3,500
Oxides and metallic lead from market-kettle	700
Market-lead	53,420

Distillation of Liquated Zinc-crust.

The liquated zinc-crust was subjected to distillation in twenty charges. Charges and time required were the same as in the first campaign.

	Lb.
Charged: Liquated zinc-crust	6,362
Charcoal	80
Result: Rich lead	5,221
Metallic scraps, charcoal, zinc, and oxides	not weighed

Coke used: 276 bushels at 40 lb. = 1·73 lb. per lb. of crust.

The residue in the retort after the discharge of the rich lead, *i.e.* metallic scraps and charcoal impregnated with metal, was not divided into two classes, as in the former case, but was all kept together, to be added in the reduction of the rich litharge at some future time. There was, therefore, no immersion in poor lead in this case, and consequently, a smaller direct product of silver than in the previous campaign.

Results

1. Control of Silver.

		Ozs.
In refined work-lead		6,165·9
Obtained and proved :—	Ozs.	
Silver tapped from test, 5,714·5 ozs. at ·989 fine	5,645·9	
Small silver pieces from test, 115 ozs. at ·970 fine	111·5	
Directly obtained	5,757·4	
In litharge, 5,200 lb. at 30 ozs. per ton	78·0	
In market-lead, 53,420 lb. at 0·33 ozs. per ton	8·9	
		5,844·3
This leaves in hearth and retort-scraps		321·6
		6,165·9

And the direct product of silver is 93·3 per cent.

2. *Control of Lead.*

	Lb.	Lb.
Refined work-lead		62,895
Obtained and accounted for:—		
Market-lead	52,420	
'Abstrich' from desilverisation, 3,500 lb. at 80 per cent. . .	2,800	
Oxide and metallic scum from market-kettle, 700 lb. at 95 per cent.	665	
Lead in zinc-crust	6,002	
		61,887
Loss, 1·7 per cent.		1,008
		62,895

In both campaigns above cited, the loss of lead, which will take place upon reduction and further treatment of oxides and other intermediate products, is not taken into account, as it could not be directly ascertained. From former experience, however, the total loss of lead in refining, i.e. adding to what is given here the loss in the further treatment of all middle products, is from 3 to 4 per cent. of the original weight of the unrefined work-lead.

It is to be regretted that the direct proof could not be furnished that the silver, *not directly* produced, is really all in the various intermediate products given above. But as long as the works are not so situated that these by-products can be worked by themselves, this cannot be done, and we must be satisfied to find at the end of each year, when the balance is struck, that the supposition has been correct.

Since new and large desilverisation kettles have been introduced and so set as to prevent an inconvenient cooling of the upper part during skimming, the silver contents of the refined lead have been brought down to the low figures of from 4 to 5 grams in a ton. These limits can now be maintained regularly. The following is a late analysis by Dr. O. Wuth, of market-lead produced from Utah and Colorado ores, and subjected to desilverisation by zinc without a preparatory refining. The sample was taken from one out of ten charges, all which were made up of lead obtained from the same ores. This lead is used by the Pittsburgh White Lead Works, which are substantially under the same control as the smelting works:

Silver	0·00042
Antimony	0·00051
Copper	0·00007
Zinc	0·00038
Iron	trace
Sulphur	0·00015
Lead	99·99844
	100·00000

By comparison with the analyses of the great majority of the foreign brands, used for the same purpose, it will be observed that the Pittsburgh lead is superior, and ranks with the best made in any part of the world.

The only unsatisfactory feature of the American method of distillation is the large consumption of fuel, which is connected with it in the present apparatus. This has led to the construction of other furnaces, which are heated either by flame-fire or gas, and though at present the general results obtained are still doubtful, the saving of fuel intended is absolutely proved.—*Transactions of the American Institute of Mining Engineers.*

Zinc. *Ornamental Application.*—The *Scientific American* has the following remarks upon the application of zinc for useful and ornamental purposes. Although the use of some ores of zinc as a means for producing brass was known to the ancients, zinc as a metal was not known; it did not for a long time meet with any use alone. In consequence, the production of this plentiful metal was a limited one. At the beginning of the present century scarce 200 tons of zinc were produced in all Europe, while at present the total production is about 125,000 tons.

It would seem as if zinc, on account of its low melting point and its relatively great power of resisting the action of the atmosphere, were excellently well adapted to the manufacture of all sorts of things; but its brittleness restricted its use within narrow limits. In 1805 it was discovered at Birmingham that zinc heated to 212° Fahr. lost its brittleness, and from that time forward zinc began to be used alone, and

especially for roofing; but this use was soon abandoned, on account of the difficulty of fastening the sheets, and has been but recently renewed. For a long time only large masses, like weights, were cast in zinc. This use was not nearly sufficient to consume the quantities of zinc which could be obtained in Silesia, and hence in 1826 the Society for the Advancement of Industry in Prussia offered a prize for the discovery of a use for zinc which should cause an essential and generally useful increase in the consumption of the metal. The prize was won by Berlin. Krigar, the chief mining councillor, first ascertained that it was possible to cast hollow pieces as well as plates and solid masses, and he had a number of utensils made of zinc for his household, but did not extend it further. It happened, however, that a friend of his named Geiss, who was the proprietor of an establishment for making fine iron castings, was hunting around for a suitable material for casting large architectural ornaments, and the idea struck him of employing zinc. Herein he found a material which melted at a low temperature, and which could be cast in moulds of moist sand, which was easily worked when cast, and which above all—for this is of the greatest importance in making very large pieces—could be easily soldered. Geiss, whose factory is still standing in Berlin, now began to experiment very zealously. Beuth and Schinkel also interested themselves in it, and Berlin soon began to employ zinc columns, capitals, architraves, cornices, and similar pieces of architectural work. The road was now broken for zinc casting, and zinc foundries sprang up rapidly in Berlin and other large cities; the price of zinc, which had fallen to \$1 50c., soon rose to \$4 50c., and the production of zinc in Europe increased considerably, as previously stated; but the returns available do not enable us to state with exactness the present production.

The increase of production of this metal, not being followed by any decrease in price, shows that the employment of zinc for casting objects of general use has been kept up, and that its use has not been limited to architecture. As soon as it became known that zinc could be so readily employed for casting, it began to be used for chandeliers and the like, where it served a good purpose as substitute for the more expensive bronze. The introduction of this use of zinc is principally due to Stier; Devaranne employed it for theatre decorations, a use founded upon the power of polished zinc to reflect the light. Finally zinc was employed for making copies of large statues, which could thus be very cheaply produced. Geiss at the very beginning cultivated this use of zinc, but it first came into practical use when Hossauer introduced a process of depositing upon the zinc structures a layer of copper by galvanic action. When thus coated, they soon acquired the appearance of genuine bronze. This use of zinc is still quite general, as it enables persons of moderate means to possess excellent works of art. They are made chiefly by Lippold and Geiss.

At present a great variety of articles are cast in zinc in Berlin; candlesticks and still smaller objects, chandeliers and gas brackets, statues and huge architectural pieces, whole monuments, and even pieces 30 feet or 40 feet high and weighing half a ton, are made of this metal. All this great variety can be made in the same establishment, for the operation is exactly the same with all. If we enter a zinc foundry, we see no huge contrivances; in the courtyard, perhaps, a copy of the colossal 'Amazon,' by Kiss, as large as the original, or perhaps a monument 20 feet high; we enter the works and find very small furnaces, small crucibles, and, in fact, only a small space for casting. The explanation of this is in the ease with which zinc is soldered. Everything, however artistic, is cast in small pieces weighing not over 10 lb. each, and then soldered together. For all such things the patterns only are kept; and when a cast is ordered a sand mould is made, the pieces cast separately and soldered together, and the joints finished off. In consequence of the small arrangements and fittings required by such foundries, their number in Berlin alone is quite considerable, there being about fifty in all. The majority of them, however, combine zinc casting with bronze casting; these are the manufactories of lamps, gas fixtures, and cheap substitutes for bronze ornaments.

The zinc foundries, in the narrower sense, whose chief productions are architectural pieces and duplicates of plastic works of art, employ about 300 hands. Berlin, where this industry originated, and where it is conducted with truly artistic taste, still takes the lead therein.

Zinc as a Disincrustant in Steam Boilers.—The disappearance of the zinc from the yellow metal plates, leaving only a spongy copper mass, in some brasswork attached to the condenser of the steamship *Albert* led M. P. O. E. Lescure to experiment as to the preservative action of zinc in steam boilers. In connection with M. Ch. Raymaly, a practical trial was undertaken with a boiler fed from the Loire. At the completion of the time examination showed that the zinc had disappeared, the scale had fallen in thin plates to the bottom of the boiler, and simply washing out was sufficient to remove all traces. The author draws attention to the effects produced under such

different conditions, in one case with sea water containing a large proportion of salt, in the other with water containing nothing but silicates; he sought to determine the causes of the disappearance of the metal and non-adherence of the scale. When two metals of a different nature are in presence of a conducting medium, an electric current is produced, flowing from the most affected to that least attacked. Under this influence the water is decomposed, the oxygen, in the case of zinc in an iron boiler, being taken up by the zinc, and the hydrogen set free. The editors of the *Annales de Chemie et de Physique* very wisely remark that probably the incessant reproduction of hydrogen gas upon the surface of the iron impedes the adherence of the deposit by preventing intimate contact with the metal, and by breaking up the pellicle at the moment of its formation. The proportion of zinc to be introduced into a boiler is estimated at 20 kilograms per 100 horse-power for three months. As scrap zinc may be used, the cost is not large.

Zinc, '*Galvanising*' *Iron*.—The following process is carried on at the works of Messrs. Alexander McCless and Co., New York. The sheets, which are prepared at the rolling mill of the firm at Phillipsburg, are brought to the works in bundles, and immersed in a vat of dilute sulphuric acid. The vat, which is lined with lead, is filled with water to about 4 in. below the top of the sheets, which are placed in the vat on their edges. Sulphuric acid is then poured in until the liquid just covers the metal. Ten bundles of sheet iron, each weighing 150 lb., are placed in the vat, and half a carboy of acid used. These bundles remain in pickle for an hour and a half, after which they are removed, 10 more bundles placed in the vat, and half a carboy of acid added. When these last bundles have been pickled and removed, the whole contents of the vat must be allowed to run off. This refuse is used to galvanise miscellaneous matters, such as ships' bolts, nails, spikes, anchors, chains, &c. The vat is filled again with fresh water and acid, and 20 bundles more are prepared in a similar manner. Upon being taken from the sulphuric acid vat the sheets are immediately immersed in an alkaline solution, potash being preferable, and the acid adhering to them neutralised. The sheets are next immersed in vats of pure water, from which they are afterwards taken, placed upon the bench, and vigorously scoured and scraped. These minute precautions are taken because it is absolutely necessary to have the sheets clean, since dirt cannot be galvanised. The sheets are next thrown back into vats of water, and afterwards immersed in vats of strong muriatic acid, which develops on the surface of the iron an affinity for the zinc. The sheets remain in the muriatic acid vat a short time, and are soon removed and placed in a large drying oven on cars, and as soon as a carload is dried it is run out to the galvanising tank. The latter is made of charcoal-bloom iron about 1 in. in thickness, and is 4 ft. deep by 23 in. wide and 11 ft. long. Its capacity is, therefore, nearly 580 gallons. It is built in brick, being surrounded by 8 in. of fire brick and 16 in. of ordinary brick. These precautions must be taken, because the tank always contains from 60,000 lb. to 80,000 lb. of melted zinc. The tanks burn out in six months, at the end of which time a new tank is built up in another place, and the melted zinc poured from the old one into the new, for the molten metal is never allowed to solidify. About 25 plates, or about half a ton of spelter, are added to the mass every day. A partition, dipping only a few inches below the top of the molten metal, extends across the top of the tank. Upon one side of this partition or strip sal-ammoniac is thrown upon the zinc, and on the other side is thrown sand, both materials floating on the surface, the partition preventing them from mingling. The operation proceeds very regularly. One person on the sal-ammoniac side of the tank takes the sheets of iron from the car on which they have been drawn from the oven, and immerses one at a time in the liquid metal. When the sheet is entirely under, he pushes its top edge over by means of a lever pivoted upon the edge of the tank. Previous to inserting the sheet, the workman has a rod, terminating in a hook in the metal, and as the sheet goes down below the surface its lower edge falls in the hook. The lever pushes over the top edge under the partition to the other side of the tank, and when this has been done the workman raises the sheet up a short distance with his hook. All this has for its object simply to keep hold of the iron while immersed in the zinc, as otherwise it might be difficult to find it when it had been passed to the other side of the tank. From the moment the sheet appears above the surface of the zinc the operation of raising it must be continued without stopping till it is entirely out of the bath, for if it stops for an instant a broad streak is left across its surface. Consequently, when the edge appears above the melted metal, it is seized by two pairs of nippers, one of which is suspended to a pulley, and hoisted out of the bath. In passing out the sheet is cleaned by the sand floating on the surface of the metal. Four men can pass 50 bundles of sheet iron through the bath in 8 hours. The sheet is next passed between three rolls to take out 'the buckle,' and afterwards through the rolls again to straighten it.

ZINC, SHEET. (Vol. iii. p. 1157.) In that article it is stated that Messrs.

Hobson and Sylvester patented a process for rolling sheet zinc for covering the roofs of houses and for sheathing ships. 44,000 tons of zinc are stated to be manufactured into sheets for various purposes, but objections have been raised to its use, on account of its rapid oxidation. This question appears to be *fully* answered.

The *Zeitschrift für Gewerbe* reproduces the calculations as to the durability of zinc made by Dr. Pettenkofer in Dingler's *Journal* some years since, but points out an error in them. Rectifying these afresh, on the basis that the oxidation of 1 square foot reaches 8·381 grams in twenty-seven years, the *Zeitschrift* finds that a sheet of zinc ½ millimètre thick would occupy 1,243 years in complete oxidation. A weight of 8·381 grams of zinc spread over the surface of a square foot would make a layer only five-thousandth of a line thick. If the sheet be 0·25 line (½ millimètre) thick, there will be 46·04 such layers, and this multiplied by 27 gives 1,243, the total number of years.

ZINC TELLURIDE. ZnTe. Tellurium and zinc combine with incandescence at a temperature between the melting point of the two substances. The resulting mass has a metallic lustre and gives a cinnabar red powder. When it is heated in a porcelain tube in a gentle current of hydrogen, ruby red crystals are deposited in the cooler parts of the tube. These crystals are regular hexagonal prisms with trihedral summits; specific gravity 6·34 at 15° C.

ZINC, WHITE. (Vol. iii. p. 1193.) M. Pierre Thomas, of Madrigne-de-Montredon, France, has introduced a new process for the direct formation of the oxide of zinc.

The improved process consists in dissolving the zinc of any zinc producing matter, ores, alloy, or metal, in hydrochloric acid, and then precipitating it in the state of hydrate by its equivalent of lime, and in calcining this hydrate at a red heat.

With pure zinc, pure acid, and pure lime, a white is thus obtained which may be compared with the finest zinc white manufactured.

There are some difficulties in obtaining a solution of chloride of zinc free from impurities. As it is not always possible to obtain pure hydrochloric acid, it is necessary, in order to secure a favourable result, to purify it with chloride of barium. By leaving the solution of zinc while hot in contact for some time with metallic zinc, all foreign metals, except manganese, are precipitated.

When once the oxide of zinc has been precipitated, and washed long enough for the washing water to be free of lime or its chloride, it is dried and calcined at a cherry red heat.

It is contended by the inventor of the process that the advantages are—1st. The manufacture of zinc white by means of metallic zinc, waste zinc, or any alloys of zinc attackable by acids. 2nd. The direct treatment of ores, calamines, or blendes. 3rd. The economical treatment of the argentiferous masses resulting from the use of zinc in desilverising lead.

ZIRCONS. (Vol. iii. p. 1193.) According to the mineral statistics of Victoria for 1876, as compiled by Mr. Thomas Couchman, Secretary of Mines, zircons, and a quantity of fine crystalline sand, which closely resembled zircon sand, has been found at Possum Hill, Orville. Zircon sand has also been discovered in the mountain streams of the Walhalla range. All the zircons are crystalline, and some nearly perfect.

Hyacinth, Jargoon. New South Wales.—The transparent red varieties are known as hyacinths, the smoky jargoon, while the gray, brown, &c., are known as zircons.

This mineral is found in granite on the Mitta Mitta, and on the Moama River, some 4 miles west of Jillamalong Hill.

Zircons are very common in the auriferous river sands and drifts, as at Uralla, Bingera, Two-mile Flat, the Cudgegong, Macquarie, Abercrombie, Shoalhaven, and other rivers.

They are of course usually more or less rolled, but occasionally the crystalline form is well preserved; they vary much in colour, from more or less colourless and transparent through pale red to crimson, brown, and opaque; they are also found of a clear transparent green, but these are rarer than the others.—Professor Liversidge, *Minerals of New South Wales.*

In granites are often observed microscopical grains of a colourless, or brown, strongly refracting mineral, which exhibit brilliant colours in polarised light and crystallise in the quadratic system. These crystals are considered by the author to be zircon. Swedish granite may be said to contain zircon as a constant accessory, whilst zircon also occurs in the granites of Switzerland, Savoy, Tyrol, and North America. Zircon is also found in the gneiss of Sweden, and in the felsite, porphyry, eurite, and hälleflinta of different localities.—A. E. Tornebohm, *Jahrb. für Min.* 1877.

ZOISITE. This mineral occurs in two forms, a black variety and a light green one. These minerals have been called by some Arfverdsonite, but neither of them have the composition of that mineral.

ADDITIONS.

So rapid has been the progress of discovery in several branches of science, and so numerous have been its applications, that, since some of the articles in this volume of the Dictionary have been printed, new and important matters have invited attention. It is therefore thought desirable to give a few brief notices here of those subjects which appear to be of the greatest practical importance, so that the information respecting them may be brought up to the latest period.

BLASTING GELATINE. (EXPLOSIVE COMPOUNDS, p. 355.) This name has been given by Mr. NOBEL—whose name is connected with nitro-glycerine and dynamite—to a new explosive compound.

This 'blasting gelatine' consists of about 95 per cent. of nitro-glycerine, and from 6 to 7 per cent. of collodion. When mixed these form a gelatinous substance which is easily made into cartridges, cakes, or balls. It is stated that this explosive compound is not in the slightest degree liable to exudation, and that it is quite impervious to water. It is fired in the same way as dynamite is, but it is said to be at least 50 per cent. stronger than that substance.

ELECTRIC LIGHT. At page 339 will be found many important particulars bearing upon the question of the application of electricity as an illuminating agent. The following remarks by Dr. C. W. SIEMENS, President of the Society of Telegraphic Engineers, made in an address to that body on January 23, are so much to the point, especially in respect to the use of electricity in our lighthouses, that it is thought desirable to give them in this place.

'Dr. TYNDALL and Mr. DOUGLASS, chief engineer to the Trinity Board, in reporting lately to the Elder Brethren upon the power of different forms of magneto-electric machines and their applicability to lighthouses, give a table showing that a machine weighing not more than 3 cwt. is capable of producing a light equal to 1,250-candle power per horse-power expenditure of mechanical energy. Assuming that each horse-power is maintained with an expenditure of 3 lb. of coal per hour (which is an excessive estimate), it would appear that 1 lb. of coal suffices to maintain a light equal to 417½ normal candles for one hour. The same amount of light would be produced by 139 cubic feet of gas of 18-candle power, for the production of which 30 lb. of coal is consumed. Assuming that of this quantity, after heating the retorts, &c., 50 per cent. is returned in the form of gas coke, there remains a net expenditure of 15 lb. of coal in the case of gas lighting to produce the effect of 1 lb. of fuel expended in electric lighting, or a ratio of 15 to 1 in favour of the latter. Add to the advantages of cheapness in maintenance and of a reduced capital expenditure in favour of the electric light, those of its great superiority in quality, and its freedom from the deleterious effects of gas in heating and polluting the atmosphere in which it burns, and it seems not improbable that it will supersede before long its competitor in many of its applications. For lighthouses, for military purposes, and for the illumination of large works and public buildings, the electric light has already made steady progress, while for domestic applications the electric candle proposed by JABLOKOFF, or modifications of the same, are likely to solve the difficulty of moderating and distributing the intense light produced by the ordinary electric lamp. The complete realisation of all the advantages of the electric light remains, however, a problem to be solved, and it would be extravagant to expect from applications on a small scale, such as have

hitherto been made, anything like the amount of relative advantage indicated by theory.'

The editor of this Dictionary was awarded the Telford Medal by the Institute of Civil Engineers for a paper on the application of Electricity as a Motive Power. In that paper he stated that the cost of obtaining mechanical power was so great, as to render almost hopeless the prospect of applying electricity as a means for driving machinery. This applied, then, equally to electric illumination. Dr. SIEMENS, GRAMME, and others (see pp. 339-340) have certainly greatly increased the probability of employing electricity, with economy, as a motive, or as an illuminating, power; but the problem of converting electrical force into mechanical power or illuminating energy, with commercial advantage, has yet to be solved.

GASES, *Condensation of, into Liquid and Solid Forms.*—The condensation of the gases belongs strictly to the *Dictionary of Chemistry*, but the future results promise to be so all-important, that it is thought necessary to give the history of the experiments made by M. CAILLETET in Paris and of M. RAOUL PICTET at Geneva in this addenda.

Binoxide of Nitrogen.—Towards the end of last year (November) M. CAILLETET liquefied the binoxide of nitrogen under a pressure of 146 atmospheres, and at the temperature of 11° of cold.

Oxygen.—The following notice is from the *Journal de Genève*:—

'One of the most interesting experiments in physics made in our time has been carried out here with great success in the laboratory belonging to the SCIENTIFIC INSTRUMENT COMPANY. Our fellow-citizen, M. RAOUL PICTET, has succeeded by the help of ingeniously disposed apparatus in obtaining oxygen in the form of a liquid. By a double circulation of sulphurous acid and carbonic acid, the latter gas, as is well known, is liquefied at a temperature of 65° of cold under a pressure of from 4 to 6 atmospheres. The details of the experiment are then as follows:—The liquefied carbonic acid is led into a tube 4 mètres in length; two compound-action pumps make a barometric vacuum in this acid, which solidifies, owing to the difference of pressure. In the interior of this first tube, containing the solidified carbonic acids, passes a smaller tube, in which there circulates a stream of oxygen. The oxygen is yielded by chlorate of potass, in a strongly made cylindrical generator with egg-shaped ends. The generator will resist a pressure of 800 atmospheres. On the morning of December 22 the apparatus was put in proper trim, and when the pressure reached 300 atmospheres, a jet of liquid oxygen spurted from the end of the tube at the moment when the compressed and frozen gas passed from this high pressure to that of a single atmosphere. The great interest of the experiment lies in the experimental demonstration supplied by it of the mechanical theory of heat, aiding, as it does, in the proof that all the gases are vapours capable of successive transmutation from the gaseous to the liquid state, and from the liquid to the solid form.'

On January 24 this interesting result was brought before the Académie des Sciences, and from the *Comptes Rendus* we translate the following official report, which gives the complete history of the discoveries:—

M. H. SAINTE-CLAIRE DEVILLE reports that M. CAILLETET repeated his experiments on the condensation of oxygen in the laboratory of the Ecole Normale on Sunday, December 16. His success was complete. If the account of them (dated December 2) was not published till to-day (December 24), the reason was that M. CAILLETET was a candidate for the place of correspondent given him by the Academy, in its sitting on December 17; that he did not care to put in on the 10th, when his testimonials were being examined, scientific work, the results of which had not been confirmed by experiments conducted in the presence of competent witnesses. And on the 17th, the day of his election, he did not think it fitting to publish a fact, important, it is true, but undiscussed in the secret committee of the 10th. Fortunately, however, I had taken the precaution, on the 30th, of sealing, and having signed by our perpetual secretary, the letter containing both the news of his discovery and the confidential expression of the honourable sentiment by which he was then guided. The priority, therefore, belongs to him unquestionably. But I ought to say that M. RAOUL PICTET's remarkable operations are not in the slightest degree discredited thereby. His *modus operandi* is altogether different from that of M. CAILLETET. The freezing process founded on the expansion of a gas or a vapour, a principle which had not hitherto been applied, and M. CAILLETET's simple apparatus, indicate instructive experimentation in future researches. It is ten years since, to my own knowledge, that M. CAILLETET began to lay the foundations of his present experiments. Being desirous of obtaining, under all circumstances, precise and rigorously measured results, he prepared, at the cost of long labour, the free air-pressure gauges, the description of which has been published in our *Comptes Rendus*, and has carefully studied the thermometric apparatus due to M. REGNAULT and M. BERTHELOT.

M. JAMIN regarded the possibility of liquefying or solidifying oxygen as now demonstrated. M. PICTET's adds little to M. CAILLETET's, since, although the former gentleman was the first to state that he had seen oxygen precipitating itself in a liquid form, the mist perceived by M. CAILLETET at the moment of expansion shows that the oxygen had ceased to be transparent, *i.e.* gaseous, and that it had become a solid or a liquid. To have seen the liquid or the mist, although unable to collect either, is a sufficient evidence of the condensation.

M. DUMAS considered that the independence of the researches of the two gentlemen in question had been fully established. Pursuing the same object, creating methods and appliances which cannot be improvised, each had arrived, by his own road, at the same result, neither having any knowledge of his rival's labours.

M. REGNAULT informed the Academy that he was present five years since at the first preliminary experiments made at Geneva by M. R. PICTET and M. DE LA RIVE with a view to obtain the liquefaction of gases.

M. BERTHELOT, while admitting the originality of M. PICTET's experiments, observed that the experiments conducted by M. CAILLETET on the liquefaction of oxygen are the necessary and foreseen result of the researches of the latter gentleman on the liquefaction of the binoxide of nitrogen, published in the *Comptes Rendus* for November 26, itself a sequel of the liquefaction of acetylene (reported on November 5). His experiment on the liquefaction of oxygen during expansion was made on December 16 at the laboratory of the Ecole Normale, before several members of the institute and other scientific gentlemen, under the amplest conditions of publicity, just a week ago. We cannot, pursued M. BERTHELOT, refuse to acknowledge the importance of the logical order of the series of experiments above detailed, which have been spread over a period of a couple of months, and have recalled the attention of our learned men to a problem which remained in suspense many years on account of practical difficulties apparently insurmountable. After being the first to show, in an unexpected manner, how probable the solution of this problem was becoming in the hands of experimenters provided with sufficient means for carrying out their experiments, M. CAILLETET has been his own first follower, by reducing the greater number of the gases hitherto deemed incoercible, namely, the binoxide of nitrogen, marsh gas, carbonic oxide, and oxygen.

Nitrogen.—M. PICTET thus announces the liquefaction of nitrogen to the French Academy:—

'Pure and dry nitrogen, compressed at about 200 atmospheres at $+30°$, and then suddenly expanded, is completely condensed. First of all appears a substance looking like a pulverised liquid, in little drops of appreciable volume; then this liquid disappears little by little from the walls towards the centre of the tube, forming at last a sort of vertical column, the axis of which follows the axis of the tube itself. The total duration of the phenomenon is about three seconds. These appearances leave no doubt whatever as to the true character of the phenomenon. I first made the experiment at home, at a temperature of $-29°$, and repeated it a large number of times in the course of yesterday, December 30, in the laboratory of the Ecole Normale, in the presence of many scientific men, among whom were several members of the Academy. The venerated M. BOUSSINGAULT, whose name I am permitted to mention, was one of the latter.'

Hydrogen.—M. RAOUL PICTET thus describes his striking experiments:—

'I have the satisfaction of communicating to you the result of an experiment made on Thursday, January 10, terminating in the liquefaction and solidification of hydrogen. I made use of exactly the same apparatus as for the liquefaction of oxygen, employing protoxide of nitrogen instead of carbonic acid.

'To obtain the hydrogen under pressure I employed the decomposition of formiate of potass by caustic potass. The hydrogen was liberated without any trace of water, and the residue is not volatile—two conditions essential for the rigorous accuracy of the observations. The temperature of the reaction is well defined and did not rise. The liberation of hydrogen proceeded with perfect regularity. The pressure reached 650 atmospheres before becoming stationary. The hydrogen disengaged corresponded to 252 litres at zero. The cold was about $-140°$ (I have not yet effected the reduction of the measurement of the temperature). When I opened the stopcock, liquid hydrogen issued with vehemence from the orifice, producing a sharp hissing sound. The jet had a steel blue colour, and was perfectly opaque for a length of about 12 centimètres. At the same time a rattling was heard upon the floor like the noise made by hail falling upon the ground, and the hissing was changed into a whistling which resembled that heard when a piece of sodium is thrown upon water. Almost immediately the jet became intermittent, and shocks were felt in the cock at each issue.

During the first stream the pressure fell from 650 atmospheres to 370. After closing the cock the pressure diminished gradually during several minutes down to 215 atmospheres; it then rose again slowly up to 225, at which it again became stationary. I reopened the cock; but the jet issued in such an intermittent manner that it was evident hydrogen had congealed in the tube. This hypothesis was demonstrated by the progressive exit of all the hydrogen when I had stopped the pumps and the production of cold. I explain the difference between these results and those which I obtained for oxygen as follows:—

'The atomic weight of hydrogen is $\frac{1}{16}$th of that of oxygen; therefore the latent heat of liquid hydrogen must be certainly ten times that of oxygen. As soon as the exit cock is opened a portion of the liquid stored in the tube evaporates, absorbing such an amount of heat by this change of state that the rest solidifies in the tube even before it can be driven out.

'During more than a quarter of an hour we had successive discharges of hydrogen through the orifice. The fog produced by the sudden expansion of the gas at the commencement of the experiment descended as far as the ground; but it ceased completely as soon as the jet became intermittent, which corresponded to the congelation of hydrogen in the interior of the tube. It is impossible to confound the vesicular fog of the gas with the appearance of the liquid jet at the outset. These different appearances are perfectly distinct, and give rise to no ambiguity.

'I know the volume of the residue, which is only carbonate of potash; and I shall be able in the next experiment to determine the density of liquid hydrogen.'

'*A Memoir sur la Liquéfaction de l'Oxygène, la Liquéfaction et la Solidification de l'Hydrogène, et sur les Théories des Changements d'état des Corps*, by M. RAOUL PICTET, will be found in the 'Archives des Sciences Physiques et Naturelles' of Geneva for January 15, 1878.

IRON, PHOSPHORUS IN. (See pp. 474 and 483.) Purification of iron as given by Mr. I. LOWTHIAN BELL in his provisional specification:—

'Most iron ores contain phosphorus, generally in the form of phosphoric acid, which, when exposed to the reducing agency of the blast furnace, loses its oxygen, leaving the phosphorus to combine with the pig iron. Malleable iron, when manufactured from pig containing an excessive quantity of phosphorus, is apt to be brittle, owing to the difficulty of sufficiently ridding the metal under treatment of this substance. Steel containing something under two-tenths of a unit per cent. of phosphorus is unmanageable in the subsequent stages of its manufacture. In the BESSEMER converter and in the open hearth no appreciable separation of the phosphorus takes place, hence pig iron containing much above one-tenth of a unit per cent. is useless as a steel-making material. I believe that the cause of this is due to the temperature of the puddling furnace, and that of the steel processes referred to, being too elevated to permit the phosphorus to be carried off in the slags. My invention consists in exposing fluid cast iron to a bath of molten oxide of iron at a much lower temperature than that employed in puddling iron. These two substances are agitated together in any suitable way, but the mode which I have found most effectual is to introduce the two into a revolving cylinder of iron, lined or 'fettled,' as it is termed, like an ordinary rotating puddling furnace. The moderate temperature at which the operation is carried on permits the phosphorus to be more perfectly removed than happens at the more elevated temperature of a puddling furnace, owing to a longer retention of the carbon, which substance confers on pig iron its fusibility. In the event, however, of the pig iron containing an excess of phosphorus, the carbon may be so diminished in quantity that consolidation takes place before the phosphorus is sufficiently well removed; in such case I add a little more fluid cast iron to the portion partially dephosphorised, and continue the operation as before. I prefer freeing the product as completely as possible from the adhering cinder, which with the phosphorus has been transferred from the pig iron. I do this because in attempting either to weld or fuse the steel or iron, the temperature is such that a portion of the phosphorus is reabsorbed by these substances from such cinder.'

In the *Journal of the Iron and Steel Institute*, No. 2 for 1877, will be found an important memoir by Mr. I. LOWTHIAN BELL on this subject, read at the meeting of the Institute on September 18, 1877.

NICKEL. 'Mémoire sur la Métallurgie du Nickel,' par M. BADOUREAU, Élève Ingénieur des Mines, is published in the *Annales des Mines*, tome xii., 5e livraison de 1877. This is a memoir of upwards of 100 pages, and it treats fully all the processes introduced of late years.

THE PHONOGRAPH. See TELEPHONE, p. 889, where an early form of the phonograph is described.

The phonograph is composed of three parts mainly—namely, a receiving, a recording, and a transmitting apparatus. The receiving apparatus consists of a curved

tube, one end of which is fitted with a mouthpiece for the convenience of speaking into it. The other end is about 2 inches in diameter, and is closed in with a disc or diaphragm of exceedingly thin metal, capable of being thrust slightly outwards or vibrated, upon gentle pressure being applied to it, from within the tube. To the centre of this diaphragm—which forms a right angle with the horizon—is fixed a small blunt steel pin, which, of course, partakes of the vibratory motion of the diaphragm. This arrangement is carried on a table and is fitted with a set screw, by means of which it can be adjusted relatively to the second part of the apparatus—the recorder. This is a brass cylinder, about 4 inches in length and 4 inches in diameter, cut with a continuous V groove from one end to the other, so that it in effect represents a large screw. Measuring along this cylinder from one end to the other there are ten of these grooves to the inch, or about forty in the whole length. The total length of this continuous groove or screw thread is about 42 feet—that is to say, that would be the length of the groove if it were stretched out in a straight line. This cylinder is mounted on a horizontal axis or shaft, carried in bearings at either end, and having its circumferential face presented to the steel point of the receiving apparatus. The shaft is prolonged for 4 inches or so beyond the ends of the cylinder, and one of the prolongations is cut with a screw thread and works in a screwed bearing. This end terminates in a handle, and as this is turned round the cylinder is not only revolved, but by means of the screwed spindle is caused to travel its whole length in front of the steel point, either backwards or forwards.

We now see that if the pointer be set in the groove in the cylinder at its commencement, and the handle turned, the groove would be traversed over the point from beginning to end, or, conversely, the point would always be presented to the groove. A voice speaking in the receiver would produce waves of sound which would cause the point to enter to greater or less depths into this groove, according to the degree of intensity given to the pressure upon the diaphragm set up by the vibrations of the sound produced. This, of course, of itself would mean nothing; but in order to arrest and preserve these sound pressures, a sheet of tin-foil is interposed, the foil being inelastic and well adapted for receiving impressions. This sheet is placed around the cylinder and its edges lightly fastened together by mouth glue, forming an endless band, and held on the cylinder at the edges by the india-rubber rings. If a person now speaks into the receiving tube and the handle of the cylinder be turned, it will be seen that the vibrations of the pointer will be impressed upon that portion of the tin-foil over the hollow groove and retained by it. These impressions will be more or less deeply marked according to the modulations and inflections of the speaker's voice. We have now a message verbally imprinted upon a strip of metal. Sound has, in fact, been converted into visible form, and we have now to translate that message by reconverting it into sound. We are about, in effect, to hear our own voice speaking from a machine the words which have just fallen from our lips. To do this we require the third portion of Mr. Edison's apparatus—the transmitter.

This consists of what may be called a conical metal drum, having its larger end open, the smaller end, which is about 2 inches in diameter, being covered with paper, which is stretched taut as is the parchment of a drum head. Just in front of this paper diaphragm is a light, flat steel spring, held in a vertical position and terminating in a blunt steel point projecting from it, and corresponding with that on the diaphragm of the receiver. The spring is connected with the paper diaphragm of the transmitter by means of a silken thread, which is placed just sufficiently in tension to cause the outer face of the diaphragm to assume a slightly convex form. This apparatus is placed on the opposite side of the cylinder to the receiver. Having set the latter apparatus back from the cylinder, and having, by turning the handle in a reverse direction, set the cylinder back to what we may term the zero point, the transmitting apparatus is advanced towards the cylinder by means of a set screw until the steel point rests without absolute pressure in the first indentation made by the point of the receiver. If now the handle be turned at the same speed as it was when the message was being recorded, the steel point will follow the line of impression and will vibrate in periods corresponding to the impressions previously produced on the foil by the point of the receiving apparatus. Vibrations of the requisite number and depth being thus communicated to the paper diaphragm, there will be produced precisely the same sounds that in the first instance were required to produce the impressions formed on the tin foil. Thus the words of the speaker will be heard issuing from the conical drum in his own voice, tinged, however, with a slight metallic tone. If the cylinder be revolved more slowly than when the message was being recorded, the voice assumes a bass tone; if more quickly, the message is given with a childish treble. These variations occur according as the vibrations are more or less frequent.—The *Times*, January 17, 1878, communicated by Mr. HENRY EDWARDS, jun.

TELEPHONE. In the *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences* for February 4, 1878, M. A. DEMOGET has a note on the telephone, in which he states that considerable improvement is made in the instrument by placing, at a short distance from the vibrating plate of BELL's telephone, one or two similar vibrating plates, the first having a circular orifice equal in diameter to the bar magnet, and the second having a larger circular opening. It is stated that this arrangement augments not only the intensity of the sounds transmitted, but gives them greater clearness.

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